For UPSC and State Civil Services Examinations

1st Edition

ENVIRONMENT

Manjunath Thamminidi

PMF IAS

ENVIRONMENT 2021-22

Simple ★ Elegant ★ Colorful ★ To-the-point ★ Engaging

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Author / Copyright Owner: Manjunath Thamminidi

Publisher: PMF IAS™

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Acknowledgements

Team PMF IAS sincerely thanks all of our contributors and supporters for helping us sustain the PMF IAS Initiative this long. You remain our cornerstone, and we are very much obliged and grateful to you.

Special thanks to our early contributors for their generous support.

Thanks to my dearest friend Mr Sri Teja from NextGen IAS for his help in the early stages of PMF IAS and his assistance in printing this book.

Special thanks to Mr Murthy from Vamshi Krishna Printers, Hyderabad, for his grateful role in the printing process of the book.

Special thanks to Anand Parmar, Rishab Sharma, Gaurav Sharma, Akash Soni, Anurag Dixit and many other aspirants for their inputs.

Last but not least, I wholeheartedly thank my family, especially my wife, for their constant support and forbearance.

Manjunath Thamminidi,

Founder, PMF IAS™

Dedicated to

All PMF IAS Contributors and Supporters

My Eternal Strength – My Family

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UPSC CSE Syllabus Relevant to Environment

UPSC CSE Prelims (GS): General issues on Environmental Ecology, Bio-diversity, and Climate Change – that do not require subject specialization.

UPSC Civil Services Mains GS I: Geographical features and their location – changes in critical geographical features (including water bodies and ice-caps) and in flora and fauna and the effects of such changes.

- ✓ Critical geographical features → Major Geographic Features that have a significant bearing on the regional/global climate/ecosystems. Examples: The Himalayas, The Polar Ice Caps, The Great Barrier Reef, The Amazon Rainforest, etc.

UPSC Civil Services Mains GS III: Conservation, environmental pollution and degradation, environmental impact assessment.

Study Guide

- Analyze the past 5-6 years' UPSC CSE Prelims and Mains question papers to understand the pattern and nature of questions asked from Environment.
- **First Reading:** Cover only the first few paragraphs (mostly the introduction part) of each topic to get a broader understanding of the scheme of things.
- Reanalyse the past 5-6 years' UPSC CSE Prelims and Mains question papers.
- **Second Reading:** Cover the entire book thoroughly.
- Take a good test series for both Prelims and Mains to identify your strengths and weakness.
- Revise, rerevise, practise test series and chart your own plan based on your strengths and weaknesses.
- Environment questions in prelims and mains are predominately based on contemporary issues and current affairs. Hence it would be best if you covered the PMF IAS current affairs thoroughly.

Color Codes

We have used color coding extensively to make it easier for you to understand what are the key concepts and focus-areas. The colour codes are as follows:

1. **Recently in News & Very Important**
2. **Important for Prelims + Mains (Colour 1 > Colour 2 > Colour 3)**
3. **Important for Prelims (Colour 1 > Colour 2 > Colour 3 | Colour 4)**
4. **Key Word or Key Phrase**

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1. Solved Environment Prelims Questions 2011-20

- The questions from the previous 4-5 years' prelims papers help us understand the nature of questions asked in pre-lims and the trend the UPSC is following.
- Most of the questions given here are explained under the relevant chapters.
- Most of the questions are current affairs based and may not be relevant for the present times. So you need not lose heart if you found some questions challenging.

1.1. 2011-2012

Q1. Which one of the following is not a site for in-situ method of conservation of flora?

a) Biosphere Reserves
b) Botanical Garden
c) National Park
d) Wildlife Sanctuary

Answer: b) Botanical Garden

Q2. What is the difference between the antelopes Oryx and Chiru?

a) Oryx is adapted to live in hot and arid areas whereas Chiru is adapted to live in steppes and semi-desert areas of cold high mountains. .
b) Oryx is poached for its antlers whereas Chiru is poached for its musk.
c) Oryx exists in western India only whereas Chiru exists in north-east India only.
d) None of the statements a, b, and c given above is correct.

Answer: a)

Q3. Among the following States, which one has the most suitable climatic conditions for the cultivation of a large variety of orchids with minimum cost of production, and can develop an export oriented industry in this field?

a) Andhra Pradesh
b) Arunachal Pradesh
c) Madhya Pradesh
d) Uttar Pradesh

- Orchids are decorative flowering plants. They grow in regions with moderate climatic conditions (Sub-tropics with decent rainfall)
- They are typical to North-Eastern states.
- Great demand for these decorative flowering plants exists in South-East Asian region.

Answer: b)

Q4. Consider the following:

1) Black-necked crane
2) Cheetah
3) Flying squirrel
4) Snow leopard

Which of the above are naturally found in India?

a) 1, 2 and 3 only

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b) 1, 3 and 4 only
c) 2 and 4 only
d) 1, 2, 3 and 4

- Black-necked crane is commonly found in the Tibetan and trans-Himalayan region. In winters, they migrate to less colder regions of the Indian Himalayas.
- The cheetah is an extinct species. They have gone extinct during the pre-independence era. Reason: They were hunted down by various Indian kings and British officers.
- Flying Squirrels are found in many Indian forests.
- The snow leopard is an 'endangered' species found in the Himalayan ranges.

Answer: b) 1, 3 and 4 only

Q5. A sandy and saline area is the natural habitat of an Indian animal species. The animal has no predators in that area but its existence is threatened due to the destruction of its habitat. Which one of the following could be that animal?

a) Indian wild buffalo
b) Indian wild ass
c) Indian wild boar
d) Indian Gazelle

Answer: b) Indian wild ass

Q6. Consider the following kinds of organisms

1) Bat
2) Bee
3) Bird

Which of the above is/are pollinating agent/agents?

a) 1 and 2 only
b) 2 only
c) 1 and 3 only
d) 1, 2 and 3

- Pollination = transfer of pollen from the stamen to the pistil.
- Bees are well-known pollinators.
- Birds help in pollination while trying to catch insects or trying to suck nectar.
- Bats help in pollination while trying to catch insects. (Bats are pollinators – Mentioned several times in the NCERTs)

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Answer: All

Q7. The 'Red Data Books' published by the International Union for Conservation of Nature and Natural Resources (IUCN) contain lists of

1) Endemic plant and animal species present in the biodiversity hotspots.
2) Threatened plant and animal species.
3) Protected sites for conservation of nature & natural resources in various countries.

Which of the statement given above is/are correct?

a) 1 & 3
b) 2 only
c) 2 & 3
d) 3 only

IUCN is an NGO. It publishes Red data book, which contains a list of 'Threatened species' (vulnerable, endangered and critically endangered).

Answer: b) 2 only

Q8. Which one of the following groups of animals belongs to the category of endangered species?

a) Great Indian Bustard, Musk Deer, Red Panda and Asiatic Wild Ass
b) Kashmir Stag, Cheetal, Blue Bull and Great Indian Bustard
c) Snow Leopard, Swamp Deer, Rhesus Monkey and Saras (Crane)
d) Lion-tailed Macaque, Blue Bull, Hanuman Langur and Cheetal

As of 2021, the status of most of these animals has changed. Outdated question.

Q9. The Himalayan Range is very rich in species diversity. Which one among the following is the most appropriate reason for this phenomenon?

a) It has a high rainfall that supports luxuriant vegetative growth.
b) It is a confluence of different bio geographical zones.
c) Exotic and invasive species have not been introduced in this region.
d) It has less human interference.

Explanation:

Options c) and d) are wrong statements.
Options a) and b) are correct statements.
Greater Diversity is due to

1. various types of forests found along the Himalayas Ranges [Shiwaliks, Himachal and Himadri].
2. Vertical zonation of vegetation [chief characteristic of Himachal and Himadri].

Answer: b)

Q10. If a tropical rain forest is removed, it does not regenerate quickly as compared to a tropical deciduous forest. This is because

a) the soil of rain forest is deficient in nutrients
b) propagules of the trees in a rain forest have poor viability
c) the rain forest species are slow-growing
d) exotic species invade the fertile soil of rain forest.

Answer: a)

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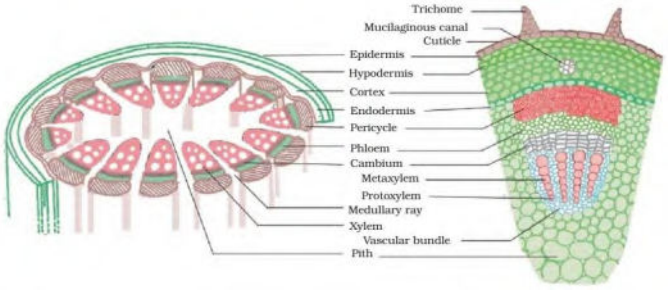
Q11. When the bark of a tree is removed in a circular fashion all around near its base, it generally dries up and dies because

a) Water from soil cannot rise to aerial parts.
b) Roots are starved of energy
c) Tree is infected by soil microbes
d) Roots do not receive oxygen for respiration



Answer: b) roots are starved of energy as the phloem (food carrying tissue) is cut off.

Q12. Consider the following:

1) Photosynthesis
2) Respiration
3) Decay of organic matter
4) Volcanic action

Which of the above add carbon dioxide to the carbon cycle on Earth?

a) 1 and 4 only
b) 2 and 3 only
c) 2,3 and 4 only
d) 1, 2, 3 and 4

Answer: c) Photosynthesis takes out CO_2 from carbon cycle. Rest all ads CO_2.

Q13. Consider the following statements: Chlorofluorocarbons, known as ozone-depleting substances, are used

1) in the production of plastic foams
2) in the production of tubeless tyres
3) in cleaning certain electronic components
4) as pressurizing agents in aerosol cans

Which of the statements given above is/are correct?

a) 1, 2 and 3 only
b) 4 only
c) 1, 3 and 4 only
d) 1, 2, 3 and 4

Answer: b)

Q14. Consider the following:

1) Carbon dioxide
2) Oxides of Nitrogen
3) Oxides of Sulphur

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Which of the above is/are the emission/emissions from coal combustion at thermal power plants ?

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

- Burning coal releases CO, CO2, sulphur dioxide and oxides of nitrogen – air pollutants.

Answer: d) 1, 2 and 3

Q15. The increasing amount of carbon dioxide in the air is slowly raising the temperature of the atmosphere, because it absorbs

a) the water vapour of the air and retains its heat.
b) the ultraviolet part of the solar radiation.
c) all the solar radiations.
d) the infrared part of the solar radiation

- Among GHGs, only water vapor has the ability to absorb both incoming (UV) and outgoing (infrared) radiation.

Answer: d) the infrared part of the solar radiation (outgoing radiation)

Q16. The formation of ozone hole in the Antarctic region has been a cause of concern. What could be the reason for the formation of this hole?

a) Presence of prominent tropospheric turbulence; and inflow of chlorofluorocarbons
b) Presence of prominent polar front and stratospheric clouds; and inflow of chloro fluorocarbons
c) Absence of polar front and stratospheric clouds; and inflow of methane and chloro fluorocarbons.
d) Increased temperature at polar region due to global warming

Answer: b)

Q17. The acidification of oceans is increasing. Why is this phenomenon a cause of concern?

1) The growth and survival of calcareous phytoplankton will be adversely affected.
2) The growth and survival of coral reefs will be adversely affected.
3) The survival of some animals that have phytoplanktonic larvae will be adversely affected.
4) The cloud seeding and formation of clouds will be adversely affected.

Which of statements given above is / are correct?

a) 1, 2 and 3 only
b) 2 only
c) 1 and 3 only
d) 1, 2, 3 and 4

Answer: d) 1, 2, 3 and 4

Q18. Regarding “carbon credits”, which one of the following statements is not correct?

a) The carbon credit system was ratified in conjunction with the Kyoto Protocol
b) Carbon credits are awarded to countries or groups that have reduced greenhouse gases below their emission quota
c) The goal of the carbon credit system is to limit the increase of carbon emission quota
d) Carbon credits are traded at a price fixed from time to time by the United Nations Environment Programme.

Answer d)

Q19. With reference to India, consider the following Central Acts:

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1) Import and Export (Control) Act, 1947.
2) Mining and Mineral Development (Regulation) Act, 1957
3) Customs Act, 1962
4) Indian Forest Act, 1927

Which of above Acts have relevance to/bearing on the biodiversity conservation in the country?

a) 1 and 3 only
b) 2,3 and 4 only
c) 1,2,3 and 4
d) None of the above Acts

Answer: c) all

Central Acts and Rules having Relevance to Biodiversity Conservation

- Fisheries Act, 1897
- Destructive Insects and Pests Act, 1914
- **The Indian Forest Act, 1927**
- Agricultural Produce (Grading and Marketing) Act,1937
- Indian Coffee Act, 1942 Import and Export (Control) Act, 1947
- Rubber (Production and Marketing) Act, 1947
- Tea Act, 1953
- **Mining and Mineral Development (Regulation) Act,1957**
- Prevention of Cruelty to Animals Act, 1960
- **Customs Act, 1962**
- Cardamom Act, 1965
- Seeds Act, 1966
- The Patents Act, 1970
- Wildlife (Protection) Act, 1972
- Marine Products Export Development Authority Act,1972
- Water (Prevention and Control of Pollution) Act, 1974
- Tobacco Board Act, 1975
- Territorial Water, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976
- Water (Prevention and Control of Pollution) Cess Act, 1977
- Maritime Zones of India (Regulation and Fishing by Foreign Vessels) Act. 1980
- Forest (Conservation) Act, 1980
- Air (Prevention and Control of Pollution) Act, 1981
- Agricultural and Processed Food Products Export Development Authority Act, 1985/1986
- Environment (Protection) Act, 1986
- Spices Board Act, 1986
- National Dairy Development Board, 1987
- Rules for the manufacture, use/import/export and storage of hazardous microorganisms/ genetically engineered organisms or cells, 1989
- **Foreign Trade (Development and Regulation) Act, 1992 [Imports and Exports (Control) Act, 1947 got repealed with the enactment of Foreign Trade (Development And Regulation) Act, 1992.]**
- Protection of Plant Varieties and Farmers' Rights (PPVFR) Act, 2001
- Biological Diversity Act, 2002

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- Plant Quarantine (Regulation of Import into India) Order, 2003
- Biological Diversity Rules, 2004
- The Food Safety and Standards Act, 2006
- Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

Q20. The National Green Tribunal Act, 2010 was enacted in consonance with which of the following provisions of the Constitution of India?

1) Right to healthy environment, construed as a part of part of Right to life under Article 21.
2) Provision of grants for raising the level of administration in the Scheduled Areas for the welfare of Scheduled Tribes under Article 275(1)

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: a)

Q21. How does National Biodiversity Authority (NBA) help in protecting the Indian agriculture?

1) NBA checks the biopiracy and protects the indigenous and traditional genetic resources.
2) NBA directly monitors and supervises the scientific research on genetic modification of crop plants.
3) Application for intellectual Property Rights related to genetic / biological resources cannot be made without the approval of NBA.

Which of the statements given above is/are correct?

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

- The top biotech regulator in India for Genetically Modified Organisms is the **Genetic Engineering Appraisal Committee (GEAC)**.

Answer: c) 1 and 3 only

Q22. Recently, 'oilzapper' was in the news. What is it?

a) It is an eco-friendly technology for the remediation of oil sludge and oil spills.
b) It is the latest technology developed for under- sea oil exploration.
c) It is a genetically engineered high biofuel yielding maize variety.
d) It is the latest technology to control the accidentally aused flames from oil wells.

Using bioremediation techniques, TERI has developed a mixture of bacteria called '**Oilzapper and Oilivorous-S**', which degrades the pollutants of oil-contaminated sites, leaving behind no harmful residues. This technique is not the only environment friendly but also highly cost-effective.

Answer: a) remediation of oil sludge and oil spills

Q23. Government of India encourages the cultivation of 'sea buckthorn'. What is the importance of this plant?

1) It helps in controlling soil erosion and in preventing desertification.
2) It is a rich source of biodiesel.

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3) It has nutritional value and is well-adapted to live in cold areas of high altitudes.
4) Its timber is of great commercial value.

Which of the statements given above is /are correct?

a) 2, 3 and 4 only
b) 1 and 3 only
c) 1, 2, 3 and 4
d) 1 only

Answer: b) 1 and 3 only

Q24. Two important rivers - one with its source in Jharkhand (and known by a different name in Odisha), and another, with its source in Odisha - merge at a place only a short distance from the coast of Bay of Bengal before flowing into the sea. This is an important site of wildlife and bio-diversity and a protected area. Which one of the following could be this?

a) Bhitarkanika
b) Chandipur-on-sea
c) Gopalpur-on-sea
d) Simlipal

- Simlipal National Park is far away from coast.
- Chandipur-on-sea and Gopalpur-on-sea are tourist destinations with resorts. There is no significant wildlife or biodiversity.

Answer: a) Bhitarkanika

Q25. A particular State in India has the following characteristics:

1) It is located on the same latitude which passes through northern Rajasthan.
2) It has over 80% of its area under forest cover.
3) Over 12% of forest cover constitutes **Protected Area Network** in this State.

Which one among the following States has all the above characteristics?

a) Arunachal Pradesh
b) Assam
c) Himachal Pradesh
d) Uttarakhand

1.2. 2013

Q1. Consider the following pairs:

1. Nokrek Bio-sphere Reserve: Garo Hills
2. Logtak (Loktak) Lake : Barail Range
3. Namdapha National Park : Dafla Hills

Which of the above pairs is/are correctly matched?

a) 1 only
b) 2 and 3 only
c) 1, 2 and 3
d) None

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Q2. Consider the following pairs about parks and rivers passing through them:

1. Corbett National Park: Ganga
2. Kaziranga National Park: Manas
3. Silent Valley National Park: Kaveri

Which of the above pairs is/are correctly matched?

a) 1 and 2
b) 3 only
c) 1 and 3
d) None

Q3. In which of the following States is lion-tailed macaque found in its natural habitat?

1. Tamil Nadu
2. Kerala
3. Karnataka
4. Andhra Pradesh

Select the correct answer using the codes given below.

a) 1, 2 and 3 only
b) 2 only
c) 1, 3 and 4 only
d) 1, 2, 3 and 4

- Lion-tailed macaque is found in Western Ghats. So, AP is the odd option.

Answer: a) 1, 2 and 3 only

Q4. Which of the following is/are unique characteristic/characteristics of equatorial forests?

1. Presence of tall, closely set trees with crowns forming a continuous canopy
2. Coexistence of a large number of species
3. Presence of numerous varieties of epiphytes

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Equatorial Vegetation

- High temperature and abundant rainfall support a luxuriant **tropical rain forest**.
- In the Amazon lowlands, the forest is so dense that it is called **'selvas'**. [selvas: A dense tropical rainforest usually having a cloud cover (**dense canopy**)]
- All plants struggle upwards (most **epiphytes**) for sunlight resulting in a peculiar layer arrangement [Canopy].

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Answer: Too easy. d) All

Q5. Consider the following fauna of India:

1. Gharial
2. Leatherback turtle
3. Swamp deer

Which of the above is/are endangered?

a) 1 and 2 only
b) 3 only
c) 1, 2 and 3
d) None

Outdated question

Q6. Consider the following

1. Star tortoise
2. Monitor lizard
3. Pygmy hog
4. Spider monkey

Which of the above found in India?

a) 1, 2 and 3 only
b) 2 and 3 only
c) 1 and 4 only
d) 1, 2, 3 and 4

- Google results don't show Spider Monkey in India.
- Spider monkeys are New World monkeys. Monkeys and apes of the Old World.
- The **New World monkeys are found in Mexico, Central America, and South America, and the Old-World monkeys are located in Africa, central to southern Asia, Japan, and India**.

Answer: a) 1, 2 and 3 only

Q7. Consider the following animals:

1. Sea cow
2. Sea horse
3. Sea lion

Which of the above is/are mammal/mammals?

a) 1 only
b) 1 and 3 only
c) 2 and 3 only

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d) 1, 2 and 3

- Sea cow (Dugong) found in shallow Indian seas is an herbivorous mammal
- Sea lion is also a mammal.
- Sea horse is a Bony Fish.

Figure 4.20 Examples of Bony fishes : (a) *Hippocampus* (b) *Catla*

Answer: b) 1 and 3 only

Q8. Mycorrhizal biotechnology has been used in rehabilitating degraded sites because mycorrhiza enables the plants to

1. resist drought and increase absorptive area
2. tolerate extremes of pH
3. Resist disease infestation

Select the correct answer using the codes given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: d) all (explained in the chapter on "Agriculture")

Q9. Consider the following organisms

1. Agaricus
2. Nostoc
3. Spirogyra

Which of the above are biofertilizers?

a) 1 and 2
b) 2 only
c) 2 and 3
d) 3 only

- Nostoc is a nitrogen-fixing cyanobacteria.

Answer: b) 2 only

Q10. Which of the following adds/add nitrogen to the soil?

1. Excretion of urea by animals
2. Burning of coal by man
3. Death of vegetation

Select the correct answer using the codes given below.

a) 1 only

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b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: c) 1 and 3 only.

Q11. Contour bunding is a method of soil conservation used in

a) desert margins, liable to strong wind action
b) low flat plains, close to stream courses, liable to flooding
c) scrublands, liable to spread of weed growth
d) None of the above

- Counter bunding is used along with terracing to protect sloped surfaces.

Answer: d) None

Q12. With reference to the usefulness of the by-products of sugar industry, which of the following statements is/are correct?

1. Bagasse can be used as biomass fuel for the generation of energy.
2. Molasses can be used as one of the feedstocks for the production of synthetic chemical fertilizers.
3. Molasses can be used for the production of ethanol.

Select the correct answer using the codes given below.

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: c) 1 and 3 only

Q13. Due to improper/indiscriminate disposal of old and used computers or their parts, which of the following are released into the environment as e-waste?

1. Beryllium
2. Cadmium
3. Chromium
4. Heptachlor
5. Mercury
6. Lead
7. Plutonium

Select the correct answer using the codes given below.

a) 1, 3, 4, 6 and 7 only
b) 1, 2, 3, 5 and 6 only
c) 2, 4, 5 and 7 only
d) 1, 2, 3, 4, 5, 6 and 7

Explanation:

- Heptachlor is a Chlorohydrocarbon (CHC) that is used as an insecticide.
- Plutonium is a radioactive metal and hence not used in computers.
- So, the answer should not contain either 4) or 7).

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Answer: b) 1, 2, 3, 5 and 6 only

Q14. Which of the following can be found as pollutants in the drinking water in some parts of India?

1) Arsenic
2) Sorbitol
3) Fluoride
4) Formaldehyde
5) Uranium

Select the correct answer using the codes given below.

a) 1 and 3 only
b) 2, 4 and 5 only
c) 1, 3 and 5 only
d) 1, 2, 3, 4 and 5

Explanation:

- The easiest option is 3) Fluoride. So, (b) can be eliminated.
- The next easiest option is Arsenic (Heavy metal). Damn!
- Nest easiest option is Uranium. Many columns are written on uranium mining and its ill effects. So, (a) also can be elevated. (a) and (b) eliminated. (c) and (d) remains.
- The knowledge of either "Sorbitol" or "Formaldehyde" will tell us the answer.
- Formaldehyde is more known than sorbitol. Googling didn't give me any authentic source that called formaldehyde a water pollutant. It is used as a preservative to preserve human organs. It finds some application in the textile, resign and wood industries.

Answer: c) 1, 3 and 5 only

- Sorbitol (glucitol) is a sugar alcohol with a sweet taste that the human body metabolizes slowly.

Q15. Which one among the following industries is the maximum consumer of water in India?

a) Engineering
b) Paper and pulp
c) Textiles
d) Thermal power

Q16. Acid rain is caused by the pollution of environment by

a) carbon dioxide and nitrogen
b) carbon monoxide and carbon dioxide
c) ozone and carbon dioxide
d) nitrous oxide and sulphur dioxide

Answer: d) nitrous oxide (laughing gas) and sulphur dioxide

Q17. Photochemical smog is a resultant of the reaction among

a) NO2, O3 and peroxyacetyl nitrate in the presence of sunlight
b) CO, O2 and peroxyacetyl nitrate in the presence of sunlight
c) CO, CO2 and NO2 at low temperature
d) High concentration of NO2, O3 and CO in the evening

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Answer: a) NO2, 03 and peroxyacetyl nitrate in the presence of sunlight

Q18. With reference to food chains in ecosystems, consider the following statements:

1. A food chain illustrates the order in which a chain of organisms feed upon each other.
2. Food chains are found within the populations of a species.
3. A food chain illustrates the numbers of each organism which are eaten by others.

Which of the statements given above is / are correct?

a) 1 only
b) 1 and 2 only
c) 1, 2 and 3
d) None

Answer: a)

Q19. Which one of the following terms describes not only the physical space occupied by an organism, but also its functional role in the community of organisms?

a) Ecotone
b) Ecological niche
c) Habitat
d) Home range

Answer: b) Niche

Q20. With reference to the food chains in ecosystems, which of the following kinds of organism is / are known as decomposer organism/organisms?

1. Virus
2. Fungi
3. Bacteria

Select the correct answer using the codes given below.

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: b)

Q21. In the grasslands, trees do not replace the grasses as a part of an ecological succession because of

a) insects and fungi
b) limited sunlight and paucity of nutrients
c) water limits and fire
d) None of the above

Answer: c)

Q22. Which one of the following is the correct sequence of ecosystems in the order of decreasing productivity?

a) Oceans, lakes, grasslands, mangroves
b) Mangroves, oceans, grasslands, lakes
c) Mangroves, grasslands, lakes, oceans

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d) Oceans, mangroves, lakes, grasslands

Answer: c) Mangroves, grasslands, lakes, oceans.

1.3. 2014

Q1. Which one of the following is the process involved in photosynthesis?

a) Potential energy is released to form free energy
b) Free energy is converted into potential energy and stored
c) Food is oxidized to release carbon dioxide and water
d) Oxygen is taken, and carbon dioxide and water vapour are given out

Answer: b)

Q2. Which of the following adds/add carbon dioxide to the carbon cycle on the planet Earth?

1. Volcanic action
2. Respiration
3. Photosynthesis
4. Decay of organic matter

Select the correct answer using the code given below.

a) 1 and 3 only
b) 2 only
c) 1, 2 and 4 only
d) 1, 2, 3 and 4

Q3. In India, the problem of soil erosion is associated with which of the following?

1. Terrace cultivation
2. Deforestation
3. Tropical climate

Select the correct answer using the code given below.

a) 1 and 2 only
b) 2 only
c) 1 and 3 only
d) 1, 2 and 3

- Terrace cultivation is a method to prevent soil erosion.
- Soil erosion occurs in all climates.

Answer: b) 2 only

Q4. Lichens, which are capable of initiating ecological succession even on a bare rock, are actually a symbiotic association of

a) algae and bacteria
b) algae and fungi
c) bacteria and fungi
d) fungi and mosses

- More of a biology question. The fungus provides shelter, water and minerals to the algae, and, in return, the alga provides food (photosynthesis).

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Q5. Conserving Biodiversity

The most important strategy for the conservation of biodiversity together with traditional human life is the establishment of

a) biosphere reserves
b) botanical gardens
c) national parks
d) wildlife sanctuaries

Answer: a) biosphere reserves

Q6. With reference to 'Eco-Sensitive Zones', which of the following statements is/are correct?

1) Eco-Sensitive Zones are the areas that are declared under the Wildlife (Protection) Act, 1972.
2) The purpose of the declaration of Eco-Sensitive Zones is to prohibit all kinds of human activities in those zones except agriculture.

Select the correct answer using the code given below.

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

- Eco-Sensitive Zones are declared under the **Environmental (Protection) Act, 1986.**
- Eco-Sensitive Zones are transitional areas where human activity is regulated but not prohibited.

Answer: d) Neither

Q7. Consider the following pairs

1) Dampa Tiger Reserve : Mizoram
2) Gumti Wildlife Sanctuary : Sikkim
3) Saramati Peak : Nagaland

Which of the above pairs is /are correctly matched?

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: c) 1 and 3 only

Q8. Consider the following pairs

Wetlands	Confluence of rivers
1. Harike Wetlands	Beas and Satluj/Sutlej
2. Keoladeo Ghana National Park	Banas and Chambal
3. Kolleru Lake	Confluence of Musi & Krishna

Which of the above pairs is/are correctly matched?

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

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Answer: a) 1 only

Q9. Which of the following have coral reefs?

1) Andaman and Nicobar Islands
2) Gulf of Kutch
3) Gulf of Mannar
4) Sunderbans

Select the correct answer using the code given below.

a) 1, 2 and 3 only
b) 2 and 4 only
c) 1 and 3 only
d) 1, 2, 3 and 4

Answer: a) 1, 2 and 3 only

Q10. Consider the following:

1) Bats
2) Bears
3) Rodents

The phenomenon of hibernation can be observed in which of the above kinds of animals?

a) 1 and 2 only
b) 2 only
c) 1, 2 and 3
d) Hibernation cannot be observed in any of the above

Answer: c) All

Q11. Among the following organisms, which one does not belong to the class of other three?

a) Crab
b) Mite
c) Scorpion
d) Spider

- Insects, Arachnids and Crustaceans are subphylum of Arthropoda.
- Mite, Scorpion and spider are Arachnids, while Crab is a Crustacean.
- I missed this concept in biology. So, I am updating it here.

Arachnids

- Spiders, scorpion, harvestmen, mites, ticks and other arachnids are members of the class Arachnida.

Crustaceans

- Crustaceans make up a large group of arthropods that includes animals such as crabs, lobsters, crayfish and shrimp. They breathe with gills and have two pairs of antennae.

Insects

- In general, insects have three-part bodies, six jointed legs, compound eyes and two antennae.

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- Bees, wasps, beetles, mosquitoes, flies, grasshoppers, ants, butterflies and moths, and dragonflies and damselflies are common types of insects.

Q12. Which one of the following is the correct sequence of a food chain?

a) Diatoms-Crustaceans-Herrings
b) Crustaceans-Diatoms-Herrings
c) Diatoms-Herrings-Crustaceans
d) Crustaceans-Herrings-Diatoms

Answer: (a)

Q13. If you travel through the Himalayas, you are Likely to see which of the following plants naturally growing there?

1. Oak
2. Rhododendron
3. Sandalwood

Select the correct answer using the code given below

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: a) 1 and 2 only

Q14. If you walk through countryside, you are likely to see some birds stalking alongside the cattle to seize the insects, disturbed by their movement through grasses, Which of the following is/are such bird/birds?

1. Painted Stork
2. Common Myna
3. Black-necked Crane

Select the correct answer using the code given below.

a) 1 and 2
b) 2 only
c) 2 and 3
d) 3 only

- Black-necked crane feeds on meadows in higher altitudes of Tibetan plateau.

Q15. Other than poaching, what are the possible reasons for the decline in the population of Ganges River Dolphins?

1. Construction of dams and barrages on rivers
2. Increase in the population of crocodiles in rivers
3. Getting trapped in fishing nets accidentally

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4. Use of synthetic fertilizers and other agricultural chemicals in crop fields in the vicinity of rivers

Select the correct answer using the code given below.

a) 1 and 2 only
b) 2 and 3 only
c) 1, 3 and 4 only
d) 1, 2, 3 and 4

Q16. With reference to two non-conventional energy sources called 'coal bed methane' and 'shale gas', consider the following 'statements:

1. Coal bed methane is the pure methane gas extracted from coal seams, while shale gas is a mixture of propane and butane only that can be extracted from fine-grained sedimentary rocks.
2. In India, abundant coal bed methane sources exist, but so far no shale gas sources have been found.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Q17. In India, cluster bean (Guar) is traditionally used as a vegetable or animal feed, but recently the cultivation of this has assumed significance. Which one of the following statements is correct in this context?

a) The oil extracted from seeds is used in the manufacture of biodegradable plastics
b) The gum made from its seeds is used in the extraction of shale gas
c) The leaf extract of this plant has the properties of anti-histamines
d) It is a source of high quality biodiesel

- Gaur is used to make water viscous before pumping into ground for hydraulic franking used to extract shale gas.

[Explained in "Geography > Economic Geography Notes"]

Q18. With reference to technologies for solar power production, consider the following statements:

1. 'Photovoltaics' is a technology that generates electricity by direct conversion of light into electricity, while 'Solar Thermal' is a technology that utilizes the Sun's rays to generate heat which is further used in electricity generation process.
2. Photovoltaics generates Alternating Current (AC), while Solar Thermal generates Direct Current (DC).
3. India has manufacturing base for Solar Thermal technology, but not for Photovoltaics.

Which of the statements given above is / are correct?

a) 1 only
b) 2 and 3 only
c) 1, 2 and 3
d) None

Answer: a) 1 only

Q19. There is some concern regarding the nanoparticles of some chemical elements that are used by the industry in the manufacture of various products. Why?

1) They can accumulate in the environment and contaminate water and soil.
2) They can enter the food chains.

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3) They can trigger the production of free radicals.

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explained under "Air Pollution"

Q20. Which of the following are some important pollutants released by steel industry in India?

1) Oxides of sulphur
2) Oxides of nitrogen
3) Carbon monoxide
4) Carbon dioxide

Select the correct answer using the code given below.

a) 1, 3 and 4 only
b) 2 and 3 only
c) 1 and 4 only
d) 1,2, 3 and 4

Answer: d) All

Q21. Brominated flame retardants are used in many household products like mattresses and upholstery. Why is there some concern about their use?

1. They are highly resistant to degradation in the environment.
2. They are able to accumulate in humans and animals.

Select the correct answer using the code given below.

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Q22. Consider the following countries:

1. Denmark
2. Japan
3. Russian Federation
4. United Kingdom
5. United States of America

Which of the above are the members of the 'Arctic Council'?

a) 1, 2 and 3
b) 2, 3 and 4
c) 1, 4 and 5
d) 1, 3 and 5

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- The Arctic Council consists of the eight Arctic States: **Canada, the Kingdom of Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, Russia, Sweden and the United States**.

Q23. With reference to 'Global Environment Facility', which of the following statements is/are correct?

a) It serves as financial mechanism for 'Convention on Biological Diversity' and 'United Nations Framework Convention on Climate Change'.
b) It undertakes scientific research on environmental issues at global level
c) It is an agency under OECD to facilitate the transfer of technology and funds to underdeveloped countries with specific aim to protect their environment.
d) Both (a) and (b)

Answer: a)

Q24. If a wetland of international importance is brought under the 'Montreux Record', what does it imply?

a) Changes in ecological character have occurred, are occurring or are likely to occur in the wetland as a result of human interference.
b) The country in which the wetland is located should enact a law to prohibit any human activity within five kilo meters from the edge of the wetland
c) The survival of the wetland depends on the cultural practices and traditions of certain communities living in its vicinity and therefore the cultural diversity therein should not be destroyed
d) It is given the status of 'World Heritage Site'

Answer: a)

Q25. With reference to a conservation organization called Wetlands International', which of the following statements is/are correct?

1) It is an intergovernmental organization formed by the countries which are signatories to Ramsar Convention.
2) It works at the field level to develop and mobilize knowledge and use the practical experience to advocate for better policies.

Select the correct answer using the code given below.

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: b) 2 only. Wetlands International is an NGO

Q26. Consider the following international agreements:

1) The International Treaty on Plant Genetic Resources for Food and Agriculture
2) The United Nations Convention to Combat Desertification
3) The World Heritage Convention

Which of the above has/have a bearing on the biodiversity?

a) 1 and 2 only
b) 3 only,
c) 1 and 3 only
d) 1, 2. and 3

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- World Heritage Convention explained in "Biodiversity", Rest two under "Fighting Climate Change-Biodiversity Protection"

Q27. The scientific view is that the increase in global temperature should not exceed 2 °C above pre-industrial level. If the global temperature increases beyond 3°C above the pre-industrial level, what can be its possible impact/impacts on the world?

1) Terrestrial biosphere tends toward a net carbon source
2) Widespread coral mortality will occur.
3) All the global wetlands will permanently disappear.
4) Cultivation of cereals will not be possible anywhere in the world.

Select the correct answer using the code given below.

a) 1 only
b) 1 and 2 only
c) 2, 3 and 4 only
d) 1, 2, 3 and 4

Answer: b) 1 and 2 only

Q28. Consider the following statements:

1) Animal Welfare Board of India is established under the Environment (Protection) Act, 1986.
2) National Tiger Conservation Authority is a statutory body.
3) National Ganga River Basin Authority is chaired by the Prime Minister.

Which of the statements given above is/ are correct?

a) 1 only
b) 2 and 3 only
c) 2 only
d) 1, 2 and 3

- Animal Welfare Board of India is established under Prevention of Cruelty to Animals Act.

Answer: b) 2 and 3 only

Q29. With reference to Bombay Natural History Society (BNHS), consider the following statements :

1. It is an autonomous organization under the Ministry of Environment and Forests.
2. It strives to conserve nature through action-based research, education and public awareness.
3. It organizes and conducts nature trails and camps for the general public.

Which of the statements given above is/are correct?

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: c) 2 and 3 only

Q30. Consider the following statements regarding 'Earth Hour'

1. It is an initiative of UNEP and UNESCO.
2. It is a movement in which the participants switch off the lights for one hour on a certain day every year.

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3. It is a movement to raise the awareness about the climate change and the need to save the planet.

Which of the statements given above is / are correct?

a) 1 and 3 only
b) 2 only
c) 2 and 3 only.
d) 1, 2 and 3

Answer: c) 2 and 3 only

Q31. Every year, a month long ecologically important campaign/festival is held during which certain communities/ tribes plant saplings of fruit-bearing trees. Which of the following are such communities/tribes?

a) Bhutia and Lepcha
b) Gond and Korku
c) Irula and Toda
d) Sahariya and Agariya

1.4. 2015

Q1. Which of the following National Parks is unique in being a swamp with floating vegetation that supports a rich biodiversity?

a) Bhitarkanika National Park
b) Keibul Lamjao National Park
c) Keoladeo Ghana National park
d) Sultanpur National park

Q2. What can be the impact of excessive/inappropriate use of nitrogenous fertilizers in agriculture?

1) Proliferation of nitrogen-fixing microorganisms in soil can occur.
2) Increase in the acidity of soil can take place
3) Leaching of nitrate to the ground-water can occur.

Select the correct answer using the code given below.

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1,2 and 3

Answer: c) 2 and 3 only

Q3. With reference to the International Union for Conservation of Nature and Natural Resources (IUCN) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which of the following statements is/are correct?

1) IUCN is an organ of the United Nations and CITES is an international agreement between governments
2) IUCN runs thousands of field projects around the world to better manage natural environments.
3) CITES is legally binding on the States that have joined it, but this Convention does not take the place of national laws.

Select the correct using the code given below.

a) 1 only

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b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: b) 2 and 3 only

Q4. With reference to 'fly ash' produced by the power plants using the coal as fuel, which of the following statements is/are correct?

1) Fly ash can be used in the production of bricks for building construction
2) Fly ash can be used as a replacement for some of the Portland cement contents of concrete
3) Fly ash is made up of silicon dioxide and calcium oxide only, and does not contain any toxic elements.

Select the correct answer using the code given below

a) 1 and 2
b) 2 only
c) 1 and 3
d) 3 only

- Fly ash does contain heavy toxic elements like arsenic, cobalt, lead etc.

Answer: a) 1 and 2

Q5. With reference to 'dugong', a mammal found in India, which of the following statements is/are correct?

1) It is a herbivorous marine animal.
2) It is found along the entire coast of India
3) It is given legal protection under Schedule 1 of the Wildlife (Protection) Act, 1972.

Select the correct answer using the code given below.

a) 1 and 2
b) 2 only
c) 1 and 3
d) 3 only

Answer: c) 1 and 3

Q6. Which one of the following is the national aquatic animal of India?

a) Saltwater crocodile
b) Olive ridley turtle
c) Gangetic dolphin
d) Gharial

Q7. Which one of the following regions of India has a combination of mangrove forest, evergreen forest and deciduous forest?

a) North Coastal Andhra Pradesh
b) South-West Bengal
c) Southern Saurashtra
d) Andaman and Nicobar Islands

Answer: d) Andaman and Nicobar Islands

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Q8. Which one of the following is associated with the issue of control and phasing out of the use of ozone-depleting substances?

a) Bretton Woods Conference
b) Montreal Protocol
c) Kyoto Protocol
d) Nagoya Protocol

Answer: b)

Q9. What is Rio+20 Conference, often mentioned in the news?

a) It is the United nations Conference on Sustainable Development
b) It is a Ministerial Meeting of the World Trade Organization
c) It is a Conference of the Inter-governmental Panel on Climate Change
d) It is a Conference of the Member Countries of the Convention on Biological Diversity

Answer: a) United nations Conference on Sustainable Development

Q10. Which of the following statements regarding 'Green Climate Fund' is/are correct?

1) It is intended to assist the developing countries in adaptation and mitigation practices to counter climate change.
2) It is founded under the aegis of UNEP, OECD, Asian Development Bank and World Bank

Select the correct answer using the code given below.

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: a) 1 only

Q11. Which one of the following National Parks has a climate that varies from tropical to subtropical, temperate and arctic?

a) Khangchendzonga National park
b) Nandadevi National Park
c) Neora Valley National Park
d) Namdapha National park

Answer: d) Namdapha National park

Q12. 'BioCarbon Fund Initiative for Sustain-able Forest Landscapes' is managed by the

a) Asian Development Bank
b) International Monetary Fund
c) United Nations Environment Programme
d) World Bank

Answer: d) World Bank

Q13. The Genetic Engineering Appraisal Committee is constituted under the

a) Food Safety and Standards Act, 2006
b) Geographical Indications of Goods (Registration and Protection) Act, 1999
c) Environment (Protection) Act, 1986

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d) Wildlife (Protection) Act, 1972

Answer: c)

Q14. 'Basel III Accord' or simply 'Basel III', often seen in the news, seeks to

a) develop national strategies for the conservation and sustainable use of biological diversity
b) improve banking sector's ability to deal with financial and economic stress and improve risk management
c) reduce the greenhouse gas emissions but places a heavier burden on developed countries
d) transfer technology from developed Countries to poor countries to enable them to replace the use of chloro-fluorocarbons in refrigeration with harmless chemicals

- Basel III accord is about improving banking by dealing with financial and economic stress.

Answer: b) improve banking sector's ability

Q15. In a particular region in India, the local people train the roots of living tree into robust bridges across the streams. As the time passes these bridges become stronger. These unique 'Living Root Bridges' are found in

a) Meghalaya
b) Himachal Pradesh
c) Jharkhand
d) Tamil Nadu

Q16. Consider the following States:

1) Arunachal Pradesh
2) Himachal Pradesh
3) Mizoram

In which of the following states do "Tropical Wet Evergreen Forests" occur?

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: c) 1 and 3 only

Q17. With reference to 'Forest Carbon Partnership Facility', which of the following statements is/are correct?

1) it is global partnership of governments, businesses, civil society and indigenous peoples
2) it provides financial aid to universities, individual scientists and institutions involved in scientific forestry research to develop eco-friendly and climate adaptation technologies for sustainable forest management
3) It assists the countries in their 'REDD+ (Reducing Emission from Deforestation and Forest Degradation+)' efforts by providing them with financial and technical assistance.

Select the correct answer using the code given below

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

- It provides financial incentives to countries (only) in their REDD+ efforts.

Answer: c) 1 and 3 only

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Q18. With reference to an organization known as 'Birdlife International' which of the following statements is/are correct?

1) It is a Global Partnership of Conservation Organizations.
2) The concept of 'biodiversity hotspots' originated from this organization.
3) It identifies the sites known/referred to as 'Important Bird and Biodiversity Areas'.

Select the correct answer using the code given below.

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: c) 1 and 3 only

Q19. In India, in which one of the following types of forests is teak a dominant tree species?

a) Tropical moist deciduous forest
b) Tropical rain forest
c) Tropical thorn scrub forest
d) Temperate forest with grasslands

Answer: a)

Q20. Which one of the following is the best description of the term "ecosystem"?

a) A community of organisms interacting with one another
b) That part of the Earth which is inhabited by living organisms
c) A community of organisms together with the environment in which they live.
d) The flora and fauna of a geographical area.

Answer: c)

Q21. With reference to bio-toilets used by the Indian Railways, consider the following statements:

1. The decomposition of human waste in the bio-toilets is initiated by a fungal inoculum.
2. Ammonia and water vapour are the only end products in this decomposition which are released into the atmosphere.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: d) Neither 1 nor 2

Q22. With reference to the Indian Renewable Energy Development Agency Limited (IREDA), which of the following statements is/are correct?

1) It is a Public Limited Government Company.
2) It is a Non – Banking Financial Company.

Select the correct answer using the code given below.

a) 1 only

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b) 2 only
c) Both 1 and 2
d) Neither 1 or 2

- IREDA is a Public Limited Government Company established as a **Non-Banking Financial Institution** in 1987 engaged in promoting, developing and extending financial assistance for setting up projects relating to new and renewable sources of energy and energy efficiency/conservation with the motto: "**Energy For Ever**".

Answer: c) Both

1.5. 2016

Q1. Consider the following pairs (2016):

Terms sometimes seen in the news	Their origin
1) Annex-I Countries	Cartagena Protocol
2) Certified Emissions Reductions	Nagoya Protocol
3) Clean Development Mechanism	Kyoto Protocol

Which of the pairs given above is/are correctly matched?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Answer: c) 3 only

Q2. With reference to an initiative called 'The Economics of Ecosystems and Biodiversity (TEEB)', which of the following statements is/are correct?

1) It is an initiative hosted by UNEP, IMF and World Economic Forum.
2) It is a global initiative that focuses on drawing attention to the economic benefits of biodiversity.
3) It presents an approach that can help decision-makers recognize, demonstrate and capture the value of ecosystems and biodiversity.

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

Q3. Which of the following statements is/are correct?

Proper design and effective implementation of UN-REDD+ Programme can significantly contribute to

1) protection of biodiversity
2) resilience of forest ecosystems
3) poverty reduction

Select the correct answer using the code given below.

a) 1 and 2 only

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b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: a) 1, 2 and 3 (UPSC Official Key)

Q4. What is 'Greenhouse Gas Protocol'?

a) It is an international accounting tool for government and business leaders to understand, quantify and man-age greenhouse gas emissions
b) It is an initiative of the United Nations to offer financial incentives to developing countries to reduce green-house gas emissions and to adopt eco-friendly technologies
c) It is an inter-governmental agreement ratified by all the member countries of the United Nations to reduce greenhouse gas emissions to specified levels by the year 2022
d) It is one of the multilateral REDD+ initiatives hosted by the World Bank

Answer: a)

Q5. With reference to 'Agenda 21', sometimes seen in the news, consider the following statements:

1) It is a global action plan for sustainable development
2) It originated in the World Summit on Sustainable Development held in Johannesburg in 2002.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

- Agenda 21 was an outcome of the **Earth Summit 1992**

Answer: a)

Q6. Consider the following statements:

1) The International Solar Alliance was launched at the United Nations Climate Change Conference in 2015.
2) The Alliance includes all the member countries of the United Nations.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

- The **International Solar Alliance (ISA)** is an alliance was initiated by **India**.
- The framework agreement opened for signatures in Marrakech in 2016, and 122 countries have joined.

Answer: a) 1 only

Q7. With reference to the Agreement at the UNFCCC Meeting in Paris in 2015, which of the following statements is/are correct?

1) The Agreement was signed by all the member countries of the UN and it will go into effect in 2017.
2) The Agreement aims to limit the greenhouse gas emissions so that the rise in average global temperature by the end of this century does not exceed 2 °C or even 1.5 °C above pre-industrial levels.

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3) Developed countries acknowledged their historical responsibility in global warming and committed to donate $ 1000 billion a year from 2020 to help developing countries to cope with climate change.

Select the correct answer using the code given below.

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

- It entered into force in November **2016**.
- It is not $1000 billion a year. It is $100 billion a year.

Answer: b) 2 only

Q8. Consider the following statements:

1) The Sustainable Development Goals were first proposed in 1972 by a global think tank called the 'Club of Rome'.
2) The Sustainable Development Goals have to be achieved by 2030.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: b) 2 only

Q9. The term 'Intended Nationally Determined Contributions' is sometimes seen in the news in the context of

a) pledges made by the European countries to rehabilitate refugees from the war-affected Middle East
b) plan of action outlined by the countries of the world to combat climate change
c) capital contributed by the member countries in the establishment of the Asian Infrastructure Investment Bank
d) plan of action outlined by the countries of the world regarding Sustainable Development Goals

- During **Warsaw Summit 2013 (COP 19)**, countries agreed to publicly outline **what actions they intend to take under a global agreement well before the Paris Summit 2015**.
- These country commitments are known as Intended Nationally Determined Contributions (INDCs).

Answer: b)

Q10. What is/are the importance/importance of the 'United Nations Convention to Combat Desertification'?

1) It aims to promote effective action through innovative national programs and supportive inter-national partnerships.
2) It has a special/particular focus on South Asia and North Africa regions, and its Secretariat facilitates the allocation of major portion of financial resources to these regions.
3) It is committed to bottom-up approach, encouraging the participation of local people in combating the desertification.

Select the correct answer using the code given below.

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

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Answer: c) 1 and 3 only

Q11. Which of the following best describes/describe the aim of 'Green India Mission' of the Government of India?

a) Incorporating environment al benefits and costs into the Union and State Budgets thereby implementing the `green accounting'
b) Launching the second green revolution to enhance agricultural output so as to ensure food security to one and all in the future
c) Restoring and enhancing forest cover and responding to climate change by a combination of adaptation and mitigation measures

Select the correct answer using the code given below.

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Answer: c) 3 only

Q12. 'Net metering' is sometimes seen in the news in the context of promoting the

a) production and use of solar energy by the households/consumers
b) use of piped natural gas in the kitchens of households
c) installation of CNG kits in motor-cars
d) installation of water meters in urban households

- Net Metering is billing mechanism for grid connected Home Rooftop Solar Installation where
  - ✓ The electricity generated by the solar panels is fed into the utility grid
  - ✓ Household draws electricity from the utility grid
- The household pays only for the difference between the energy units it consumes from the grid and the energy units fed into the grid. This is measured by a bi-directional meter called Net Meter.

Answer: a)

Q13. On which of the following can you find the Bureau of Energy Efficiency Star Label?

a) Ceiling fans
b) Electric geysers
c) Tubular fluorescent lamps

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: d) all

Q14. In the cities of our country, which among the following atmospheric gases are normally considered in calculating the value of Air Quality Index?

1) Carbon dioxide
2) Carbon monoxide
3) Nitrogen dioxide

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4) Sulphur dioxide
5) Methane

Select the correct answer using the code given below.

a) 1, 2 and 3 only
b) 2, 3 and 4 only
c) 1, 4 and 5 only
d) 1, 2, 3, 4 and 5

- The AQI will consider eight pollutants (**PM10, PM2.5, NO_2, SO_2, CO, O_3, NH_3, and Pb**).

Answer: b) 2, 3 and 4 only

Q15. Which of the following are the key features of 'National Ganga River Basin Authority (NGRBA)'?

1) River basin is the unit of planning and management.
2) It spearheads the river conservation efforts at the national level.
3) One of the Chief Ministers of the States through which the Ganga flows becomes the Chairman of NGRBA on rotation basis.

Select the correct answer using the code given Below.

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: a) 1 and 2 only

Q16. 'Gadgil Committee Report' and 'Kasturirangan Committee Report', sometimes seen in the news, are related to

1) constitutional reforms
2) Ganga Action Plan
3) linking of rivers
4) **protection of Western Ghats**

Q17. What is/are unique about 'Kharai camel', a breed found in India?

1) It is capable of swimming up to three kilometres in seawater.
2) It survives by grazing on mangroves.
3) It lives in the wild and cannot be domesticated.

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: a) 1 and 2 only

Q18. Recently, our scientists have discovered a new and distinct species of banana plant which attains a height of about 11 metres and has orange-coloured fruit pulp. In which part of India has it been discovered?

a) **Andaman Islands**

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b) Anaimalai Forests
c) Maikala Hills
d) Tropical rain forests of northeast

Q19. With reference to 'Red Sanders', sometimes seen in the news, consider the following statements:

1) It is a tree species found in a part of South India.
2) It is one of the most important trees in the tropical rain forest areas of South India.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

In Geography > Indian Geography > Natural vegetation of India > Dry Deciduous Forests

Q20. Recently, for the first time in our country, which of the following States has declared a particular butterfly as 'State Butterfly'?

a) Arunachal Pradesh
b) Himachal Pradesh
c) Karnataka
d) Maharashtra

Q21. In which of the following regions of India are you most likely to come across the `Great Indian Hornbill' in its natural habitat?

a) Sand deserts of northwest India
b) Higher Himalayas of Jammu and Kashmir
c) Salt marshes of western Gujarat
d) Western Ghats

1.6. 2017

Q1. The term M-STRIPES' is sometimes seen in the news in the context of

a) Captive breeding of Wild Fauna
b) Maintenance of Tiger Reserves
c) Indigenous Satellite Navigation System
d) Security of National Highways

Q2. Recently there was a proposal to translocate some of the lions from their natural habitat in Gujarat to which one of the following sites?

a) Corbett National Park
b) Kuno Palpur Wildlife Sanctuary
c) Mudumalai Wildlife Sanctuary
d) Sariska National Park

Q3. In India, if a species of tortoise is declared protected under Schedule I of the Wildlife (Protection) Act, 1972, what does it imply?

a) It enjoys the same level of protection as the tiger.

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b) It no longer exists in the wild, a few individuals are under captive protection; and now it is impossible to prevent its extinction.
c) It is endemic to a particular region of India.
d) Both (b) and (c) stated above are correct in this context.

Q4. According to the Wildlife (Protection) Act, 1972, which of the following animals cannot be hunted by any person except under some provisions provided by law?

1) Gharial
2) Indian wild ass
3) Wild buffalo

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Q5. If you want to see gharials in their natural habitat, which one of the following is the best place to visit?

a) Bhitarkanika Mangroves
b) Chambal River
c) Pulicat Lake
d) Deepor Beel

Q6. From the ecological point of view, which one of the following assumes importance in being a good link between the Eastern Ghats and the Western Ghats?

a) Sathyamangalam Tiger Reserve
b) Nallamala Forest
c) Nagarhole National Park
d) Seshachalam Biosphere Reserve

Q7. Consider the following statements in respect of Trade Related Analysis of Fauna and Flora in Commerce (TRAFFIC):

1) TRAFFIC is a bureau under United Nations Environment Programme (UNEP).
2) The mission of TRAFFIC is to ensure that trade in wild plants and animals is not a threat to the conservation of nature.

Which of the above statements is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Q8. Due to some reasons, if there is a huge fall in the population of species of butterflies, what could be its likely consequence/consequences?

1) Pollination of some plants could be adversely affected.
2) There could be a drastic increase in the fungal infections of some cultivated plants.
3) It could lead to a fall in the population of some species of wasps, spiders and birds.

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Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Q9. Biological Oxygen Demand (BOD) is a standard criterion for

a) Measuring oxygen levels in blood
b) Computing oxygen levels in forest ecosystems
c) Pollution assay in aquatic ecosystems
d) Assessing oxygen levels in high altitude regions

Q10. In the context of solving pollution problems, what is/are the advantage/advantages of bioremediation technique?

1) It is a technique for cleaning up pollution by enhancing the same biodegradation process that occurs in nature.
2) Any contaminant with heavy metals such as cadmium and lead can be readily and completely treated by bioremediation using microorganisms.
3) Genetic engineering can be used to create microorganisms specifically designed for bioremediation.

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Q11. In the context of mitigating the impending global warming due to anthropogenic emissions of carbon dioxide, which of the following can be the potential sites for carbon sequestration?

1) Abandoned and uneconomic coal seams
2) Depleted oil and gas reservoirs
3) Subterranean deep saline formations

Select the correct answer using the code given below:

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

Q12. It is possible to produce algae based biofuels, but what is/are the likely limitation(s) of developing countries in promoting this industry?

1) Production of algae based biofuels is possible in seas only and not on continents.
2) Setting up and engineering the algae based biofuel production requires high level of expertise/technology until the construction is completed.
3) Economically viable production necessitates the setting up of large scale facilities which may raise ecological and social concerns.

Select the correct answer using the code given below:

a) 1 and 2 only

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b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Q13. With reference to 'Global Climate Change Alliance', which of the following statements is/are correct?

1) It is an initiative of the European Union.
2) It provides technical and financial support to targeted developing countries to integrate climate change into their development policies and budgets.
3) It is coordinated by World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).

Select the correct answer using the code given below:

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

Q14. Consider the following statements:

1) Climate and Clean Air Coalition (CCAC) to reduce Short Lived Climate Pollutants is a unique initiative of G20 group of countries.
2) The CCAC focuses on methane, black carbon and hydrofluorocarbons.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

1.7. 2018

Q1. Why is a plant called Prosopis juliflora often mentioned in news?

a) Its extract is widely used in cosmetics.
b) It tends to reduce the biodiversity in the area in which it grows.
c) Its extract is used in the synthesis of pesticides.
d) None of the above

Q2. Consider the following statements:

1) Most of the world's coral reefs are in tropical waters.
2) More than one-third of the world's coral reefs are located in the territories of Australia, Indonesia and Philippines.
3) Coral reefs host far more number of animal phyla than those hosted by tropical rainforests.

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

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Q3. With reference to solar power production in India, consider the following statements:

1) India is the third largest in the world in the manufacture of silicon wafers used in photovoltaic units.
2) The solar power tariffs are determined by the Solar Energy Corporation of India.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Q4. Which of the following statements best describes "carbon fertilization"?

a) Increased plant growth due to increased concentration of carbon dioxide in the atmosphere
b) Increased temperature of Earth due to increased concentration of carbon dioxide in the atmosphere
c) Increased acidity of oceans as a result of increased concentration of carbon dioxide in the atmosphere
d) Adaptation of all living beings on Earth to the climate change brought about by the increased concentration of carbon dioxide in the atmosphere

Answer: a)

Q5. The term "sixth mass extinction/sixth extinction" is often mentioned in the news in the context of the discussion of

a) Widespread monoculture practices in agriculture and large-scale commercial farming with indiscriminate use of chemicals in many parts of the world that may result in the loss of good native ecosystems.
b) Fears of a possible collision of a meteorite with the Earth in the near future in the manner it happened 65 million years ago that caused the mass extinction of many species including those of dinosaurs. .
c) Large scale cultivation of genetically modified crops in many parts of the world and promoting their cultivation in other parts of the world which may cause the disappearance of good native crop plants and the loss of food biodiversity.
d) Mankind's over-exploitation/misuse of natural resources, fragmentation/loss of natural habitats, destruction of ecosystems, pollution and global climate change.

Answer: d)

Q6. Which of the following is/are the possible consequence/s of heavy sand mining in riverbeds? (2018)

1) Decreased salinity in the river
2) Pollution of groundwater
3) Lowering of the water-table

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1 ,2 and 3

Answer: b) 2 and 3 only

Q7. Which of the following has/have shrunk immensely/dried up in the recent past due to human activities?

1) Aral Sea

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2) Black Sea
3) Lake Baikal

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3
c) 2 only
d) 1 and 3

Answer: a) 1 only

Q8. How is the National Green Tribunal (NGT) different from the Central Pollution Control Board (CPCB)

1) The NGT has been established by an Act whereas the CPCB has been created by an executive order of the Government.
2) The NGT provides environmental justice and helps reduce the burden of litigation in the higher courts whereas the CPCB promotes cleanliness of streams and wells and aims to improve the quality of air in the country.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: b) 2 only

Q9. Consider the following statements:

1) The definition of "Critical Wildlife Habitat" is incorporated in the Forest Rights Act, 2006.
2) For the first time in India, Baigas have been given Habitat Rights.
3) Union Ministry of Environment, Forest and Climate Change officially decides and declares Habitat Rights for Primitive and Vulnerable Tribal Groups in any part of India.

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

- 2016: **Baiga tribe** (living in the sal forests of Maikal Hills) in Madhya Pradesh is the first to get habitat rights in India.
- This is for the first time habitat rights have been given under the Forest Rights Act of 2006.
- Baiga community is one of the **75 particularly vulnerable tribal groups**, or PVTGs, who are eligible to get habitat rights under FRA.
- The definition of **habitat rights** was incorporated through an amendment in the FRA in 2012.
- As per the amendment, the district level committee shall ensure that all PVTGs receive habitat rights, in consultation with these groups, after filing claims before the gram sabha.
- It is MoTA that decides habitat rights.

Answer: 1 and 2 only.

Q10. In which one of the following States is Pakhui Wildlife Sanctuary located?

a) Arunachal Pradesh

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b) Manipur
c) Meghalaya
d) Nagaland

Q11. The Partnership for Action on Green Economy (PAGE), a UN mechanism to assist countries transition towards greener and more inclusive economies, emerged at

a) The Earth Summit on Sustainable Development 2002, Johannesburg
b) The United Nations Conference on Sustainable Development 2012, Rio de Janeiro
c) The United Nations Framework Convention on Climate Change 2015, Paris
d) The World Sustainable Development Summit 2016, New Delhi

Answer: b) Rio+20

Q12. Momentum for Change: Climate Neutral Now" is an initiative launched by

a) The Intergovernmental Panel on Climate Change
b) The UNEP Secretariat
c) The UNFCCC Secretariat
d) The World Meteorological Organisation

Answer: c) UNFCCC

Q13. With reference to the 'Global Alliance for Climate Smart Agriculture (GACSA)', which of the following statements is/are correct?

1) GACSA is an outcome of the Climate Summit held in Paris in 2015.
2) Membership of GACSA does not create any binding obligations.
3) India was instrumental in the creation of GACSA.

Select the correct answer using the code given

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: 2) only

Q14. With reference to the circumstances in Indian agriculture, the concept of "Conservation Agriculture" assumes significance. Which of the following fall under the Conservation Agriculture?

1) Avoiding the monoculture practices
2) Adopting minimum tillage
3) Avoiding the cultivation of plantation crops
4) Using crop residues to cover soil surface
5) Adopting spatial and temporal crop sequencing/crop rotations

Select the correct answer using the code given below:

a) 1, 3 and 4
b) 2, 3, 4 and 5
c) 2, 4 and 5
d) 1, 2, 3 and 5

Answer: c) 2, 4 and 5

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Q15. With reference to organic farming in India, consider the following statements:

1) The National Programme for Organic Production' (NPOP) is operated under the guidelines and directions of the Union Ministry of Rural Development.
2) The Agricultural and Processed Food Products Export Development Authority' (APEDA) functions as the Secretariat for the implementation of NPOP.
3) Sikkim has become India's first fully organic State.

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Answer: b) 2 and 3 only

Q.16 With reference to agricultural soils, consider the following statements:

1) A high content of organic matter in soil drastically reduces its water holding capacity.
2) Soil does not play any role in the Sulphur cycle.
3) Irrigation over a period of time can contribute to the salinization of some agricultural lands.

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: b) 3 only

1.8. 2019

Detailed explanation for every single question of 2019 and 2020 is given under relevant chapters.

Q1. As per the Solid Waste Management Rules, 2016 in India, which one of the following statements is correct?

a) Waste generator has to segregate waste into 5 categories.
b) The Rules are applicable to notified urban local bodies, notified towns and all industrial township only.
c) The Rules provide for exact and elaborate criteria for the identification of sites for landfills and waste processing facilities.
d) It is mandatory on the part of waste generator that the waste generated in one district cannot be moved to another district.

Answer: c)

Q2. Consider the following pairs:

Wildlife: Naturally found in

1) Blue finned mahseer: Cauvery river
2) Irrawaddy dolphin: Chambal river
3) Rusty spotted cats: Eastern ghats

Which one of the pair given above are correctly matched?

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a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: c)

Q3. Consider the following statements :

1) As per law, the Compensatory Afforestation Fund Management and Planning Authority exists at both National and State levels.
2) People's participation is mandatory in the compensatory afforestation programmes carried out under the Compensatory Afforestation Fund Act, 2016.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: a)

Q4. Consider the following statements:

1) Asiatic lion naturally found in India only
2) Double-humped camel is naturally found in India only
3) One-horned rhinoceros is naturally found in India only

Which one of the statement given above is/are correct?

a) 1 only
b) 2 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: a)

Q5. Consider the following statements:

1) Some species of turtle are herbivores
2) Some species of fish are herbivores
3) Some species of marine mammals are herbivores
4) Some species of snakes are viviparous

Which of the statement given above are correct?

a) 1 and 3 only
b) 2, 3 and 4 only
c) 2 and 4 only
d) 1, 2, 3 and 4

Answer: d)

Q6. Consider the following statements:

1) Agricultural soils release nitrogen oxides into environment.

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2) Cattle release ammonia into environment.
3) Poultry industry release reactive nitrogen compounds into environment.

Which of the statements given above is/are correct?

a) 1 and 3 only
b) 2 and 3 only
c) 2 only
d) 1, 2 and 3

Answer: d)

Q7. Consider the following statements:

1) Under Ramsar convention, it is mandatory on the part of the Government on India in protect and conserve all the wetlands in the territory of India
2) The Wetlands (Conservation and Management) Rules, 2010 were framed by the Government of India based on the recommendations of Ramsar convention.
3) The Wetlands (Conservation and Management) Rules, 2010 also encompass the drainage area or catchment regions of the wetlands as determined by the authority

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Answer: b); but according to the official UPSC Key, the answer is c) 3 only

Q8. Consider the following statements: The Environment Protection Act, 1986 empowers the Government of India to

1) State the requirement of public participation in the process of environmental protection, and the procedure and manner in which it is sought.
2) Lay down the standards for emission or discharge of environmental pollutants from various sources.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: b)

Q9. Consider the following states :

1) Chhattisgarh
2) Madhya Pradesh
3) Maharashtra
4) Odisha

With reference to the states mentioned above, in terms of percentage of forest cover to the total area of State, which one of the following is the correct ascending order?

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a) 2-3-1-4
b) 2-3-4-1
c) 3-2-4-1
d) 3-2-1-4

Answer: c)

Q10. Consider the following:

1) Carbon monoxide
2) Methane
3) Ozone
4) Sulphur dioxide

Which of the above are released into the atmosphere due to the burning of crop/biomass residue?

a) 1 and 2 only
b) 2, 3 and 4 only
c) 1 and 4 only
d) 1,2,3 and 4

Answer: d)

Q11. For the measurement/estimation of which of the following are satellite images/remote sensing data used?

1) Chlorophyll content in the vegetation of a specific location
2) Greenhouse gas emissions from rice paddies of a specific location
3) Land surface temperatures of a specific location

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Answer: d)

Q12. In India, 'extended producer responsibility' was introduced as an important feature in which of the following?

a) The Bio-medical Waste (management and handling) rules,1998
b) The Recycled Plastic (manufacturing and usage) rules, 1999
c) The e-Waste (Management & handling) rules, 2011
d) The food safety and standard regulations, 2011

Answer: c)

Q13. In India, the use of carbofuran, methyl parathion phorate and triazophos is viewed with apprehension. These chemicals are used as

a) pesticides in agriculture
b) preservatives in processed foods
c) fruit-ripening agents
d) moisturizing agents in cosmetics

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Answer: a)

Q14. In the context of the proposals to the use of hydrogen-enriched CNG (H-CNG) as fuel for buses in public transport, consider the following statements

1) The main advantage of the use of H-CNG is the elimination of carbon monoxide emissions.
2) H-CNG as fuel reduces carbon dioxide and hydrocarbon emissions.
3) Hydrogen up to one-fifth by volume can be blended with CNG as fuel for buses.
4) H-CNG makes the fuel less expensive than CNG.

Which of the statements given above is/are correct?

a) 1 only
b) 2 and 3 only
c) 4 only
d) 1, 2, 3 and 4

Answer: c)

Q15. In the context of which of the following do some scientists suggest the use of cirrus cloud thinning technique and the injection of sulphate aerosol into stratosphere?

a) Creating the artificial rains in some regions
b) Reducing the frequency and intensity of tropical cyclones
c) Reducing the adverse effects of the solar wind on the earth
d) Reducing the global warming

Answer: d)

Q16. In the context of which one of the following are the terms pyrolysis and plasma gasification mentioned?

a) Extraction of earth element
b) natural gas extractions technologies
c) Hydrogen fuel-based automobiles
d) Waste to energy technologies

Answer: d)

Q17. Recently, there was a growing awareness in our country about the importance of Himalayan nettle (*Girardinia diversifolia*) because it is found to be a sustainable source of

a) anti-malarial drug
b) biodiesel
c) pulp for paper industry
d) textile fibre

Answer: d)

Q18. Which of the following statements are correct about the deposits of methane hydrate?

1) Global warming might trigger the release of methane gas from these deposits
2) Large deposits of 'methane hydrate' are found in Arctic Tundra and under the seafloor.
3) Methane in atmosphere oxidizes to carbon dioxide after a decade or two.

Select the correct answer using the code given below:

a) 1 and 2 only

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b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: d)

Q19. Which one of the following are Agasthyamala biosphere reserve?

a) Neyyar, Peppara and Shendurney wildlife sanctuaries and Kalakad Mundanthurai Tiger Reserve
b) Mudumalai Sathayamangalam and Wayanad wildlife sanctuaries and Silent Valley National Park
c) Kaundinya Gundla Bhrameshwaram and Papikonda wildlife sanctuaries and Mukurthi National Park
d) Kawal and Shree Venkateshwara wildlife sanctuaries; and Nagarjunasagar-Srisailam tiger reserve

Answer: a)

Q20. Which one of the following national parks lies completely in the Temperate alpine zone?

a) Manas national park
b) Namdapha national park
c) Neora valley national park
d) Valley of flower national park

Answer: d)

Q21. Why is there a great concern about the microbeads that are released into environment?

a) They are considered harmful to marine ecosystem
b) They are considered to cause skin cancer in children
c) They are small enough to absorbed by crop plants in irrigated fields
d) They are often found to be used as food adulterants

Answer: a)

1.9. 2020

Q1. According to India's National Policy on Biofuels, which of the following can be used as raw materials for the production of biofuels?

1) Cassava
2) Damaged wheat grains
3) Groundnut seeds
4) Horse gram
5) Rotten potatoes
6) Sugar beet

Select the correct answer using the code given below:

a) 1, 2, 5 and 6 only
b) 1, 3, 4 and 6 only
c) 2, 3, 4 and 5 only
d) 1, 2, 3, 4, 5 and 6

Answer: a)

Q2. Among the following Tiger Reserves, which one has the largest area under "Critical Tiger Habitat"?

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a) Corbett
b) Ranthambore
c) Nagarjunsagar-Srisailam
d) Sunderbans

Answer: c)

Q3. Consider the following statements:

1) 36% of India's districts are classified as "overexploited" or "critical" by the Central Ground Water Authority (CGWA).
2) CGWA was formed under the Environment (Protection) Act.
3) India has the largest area under groundwater irrigation in the world.

Which of the statements given above is/are correct?

a) 1 only
b) 2 and 3 only
c) 2 only
d) 1 and 3 only

Answer: b) 2 and 3 only

Q4. Consider the following statements:

1) Coal ash contains arsenic, lead and mercury.
2) Coal-fired power plants release sulphur dioxide and oxides of nitrogen into the environment.
3) High ash content is observed in Indian coal.

Which of the statements given above is/are correct ?

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Answer: d)

Q5. If a particular plant species is placed under Schedule VI of The Wildlife Protection Act, 1972, what is the implication?

a) A licence is required to cultivate that plant.
b) Such a plant cannot be cultivated under any circumstances.
c) It is a Genetically Modified crop plant.
d) Such a plant is invasive and harmful to the ecosystem.

Answer: a) a license is required

Q5. In rural road construction, the use of which of the following is preferred for ensuring environmental sustainability or to reduce carbon footprint?

1) Copper slag
2) Cold mix asphalt technology
3) Geotextiles
4) Hot mix asphalt technology
5) Portland cement

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Select the correct answer using the code given below:

a) 1, 2 and 3 only
b) 2, 3 and 4 only
c) 4 and 5 only
d) 1 and 5 only

Answer: a)

Q6. Steel slag can be the material for which of the following?

1) Construction of base road
2) Improvement of agricultural soil
3) Production of cement

Select the correct answer using the code given below:

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: d)

Q7. Which of the following are the most likely places to find the musk deer in its natural habitat?

1) Askot Wildlife Sanctuary
2) Gangotri National Park
3) Kishanpur Wildlife Sanctuary
4) Manas National Park

Select the correct answer using the code given below

a) 1 and 2 only
b) 2 and 3 only
c) 3 and 4 only
d) 1 and 4 only

Answer: a)

Q8. Which of the following are the reasons/factors for exposure to benzene pollution?

1) Automobile exhaust
2) Tobacco smoke
3) Wood burning
4) Using varnished wooden furniture
5) Using products made of polyurethane

Select the correct answer using the code given below:

a) 1, 2 and 3 only
b) 2 and 4 only
c) 1, 3 and 4 only
d) 1, 2, 3, 4 and 5

Answer: d) all

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Q9. Which of the following Protected Areas are located in Cauvery basin?

1) Nagarhole National park
2) Papikonda National park
3) Sathyamangalam Tiger Reserve
4) Wayanad Wildlife sanctuary

Select the correct answer using the code given below:

a) 1 and 2 only
b) 3 and 4 only
c) 1, 3 and 4 only
d) 1,2,3 and 4

Answer: c)

Q10. Which one of the following protected areas is well-known for the conservation of a sub-species of the Indian swamp deer (Barasinga) that thrives well in hard ground and is exclusively graminivorous?

a) Kanha National Park
b) Manas National Park
c) Mudumalai Wildlife Sanctuary
d) Tal Chhapar Wildlife Sanctuary

Q11. Which one of the following statements best describes the term 'Social Cost of Carbon'? It is a measure, in monetary value, of the

a) long-term damage done by a tonne of CO_2 emissions in a given year.
b) requirement of fossil fuels for a country to provide goods and services to its citizens, based on the burning of those fuels.
c) efforts put in by a climate refugee to adapt to live in a new place.
d) contribution of an individual person to the carbon footprint on the planet Earth.

Answer: a)

Q12. With reference to India's biodiversity, Ceylon frogmouth, Coppersmith barbet, Gray-chinned minivet and White- throated redstart are

a) Birds
b) Primates
c) Reptiles
d) Amphibians

Q13. With reference to India's Desert National Park, which of the following statements are correct?

1) It is spread over two districts.
2) There is no human habitation inside the Park.
3) It is one of the natural habitats of the Great Indian Bustard.

Select the correct answer using the code given below;

a) 1 and 2 only
b) 2 und 3 only
c) 1 and 3 only
d) 1, 2 and 3

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Answer: c)

Q14. With reference to Indian elephants, consider the following statements :

1) The leader of an elephant group is a female
2) The maximum gestation period can be 22 months.
3) An elephant can normally go on calving till the age of 40 years only.
4) Among the States in India, the highest elephant population is in Kerala.

Which of the statements given above is/ are correct?

a) 1 and 2 only
b) 2 and 4 only
c) 3 only
d) 1, 3 and 4 only

Answer: a) 1 & 2 only

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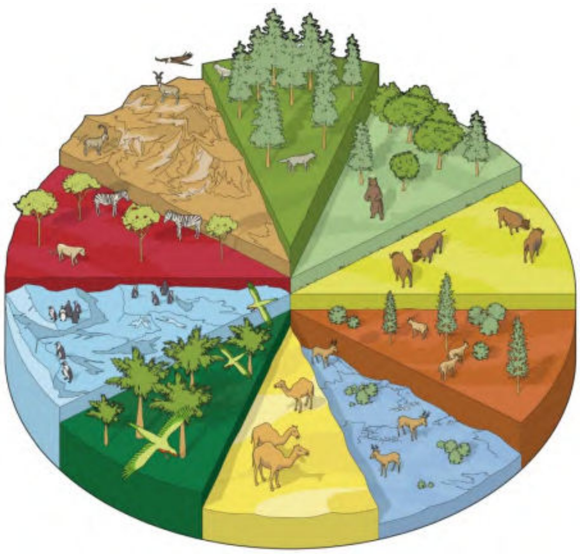
2. Environment, Habitat and Ecosystem

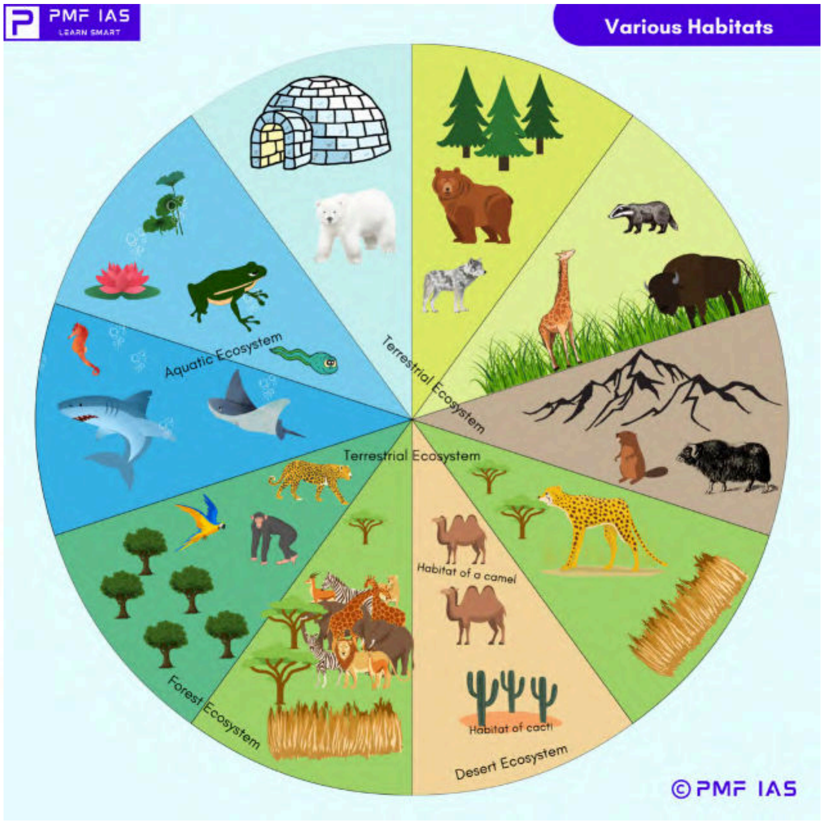
2.1. Environment

- The environment is the natural component in which **biotic (living)** and **abiotic (non-living:** climate, weather, the natural phenomenon like lightning, etc.) factors interact among themselves and with each other.
- These interactions shape the **habitat** and the **ecosystem** of an organism or that of an **ecological community**.
- In the biological sense, the environment constitutes the physical (nutrients, water, air, climate) and biological factors (biomolecules, organisms) along with their **chemical interactions** (chemical cycles – carbon cycle, nitrogen cycle etc.) that affect an organism or a group of organisms.
- All organisms depend on the environment to carry out their natural life processes and meet their physical requirements (food, energy, water, oxygen, shelter, etc.).

2.2. Habitat

- **Habitat is the physical environment in which an organism lives (address of an organism)**.
- **Many habitats make up the environment**.





- A single habitat may be common for more than one organism which have **similar requirements**.
- For example, a single aquatic habitat may support a fish, frog, crab, phytoplankton, and many others.
- The various species sharing a habitat thus have the same 'address'. E.g., forest, river, lake, etc.

2.2.1. Difference Between Habitat and Environment

- **A habitat always has life** in it, whereas the environment does not necessarily have life in it ➔ **All habitats are environments, but all environments are not habitats**.
- A **habitat** is always a **preference of one species**.

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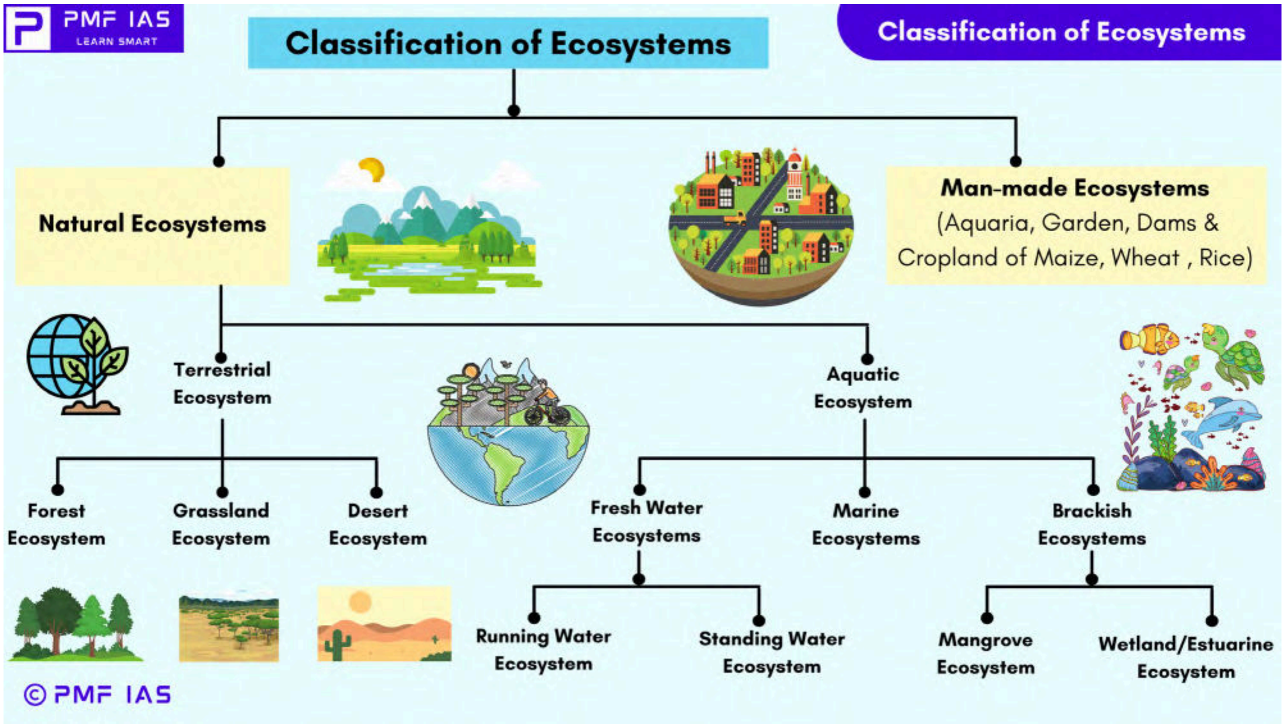
- An **environment** could be a **preference of many species** that could eventually become many habitats.
- Usually, the **environment governs the properties of a habitat, but not vice versa**.

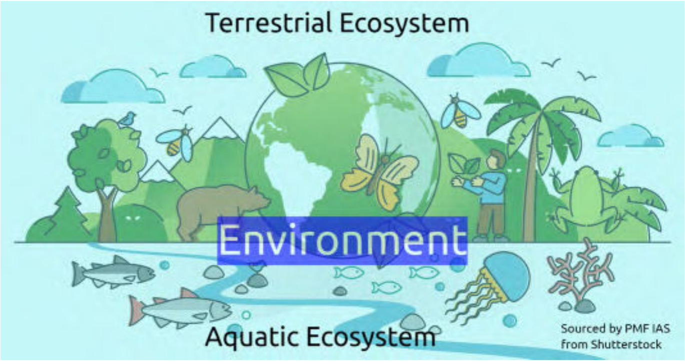
2.3. Ecosystem

- An ecosystem can be visualized as a **functional unit of nature**, where living organisms (producers, consumers, and decomposers) interact among themselves and also with the surrounding physical environment.
- An ecosystem can be of any size but usually encompasses **specific and limited species**. E.g., Aquatic Ecosystem. (**This is how 'ecosystem' is different from 'environment'**)
- In the ecosystem, biotic and abiotic components are linked together through **nutrient cycles** and **energy flows**.
- Everything that lives in an ecosystem is **dependent** on the other species and elements that are also part of that **ecological community**.
- If one part of an ecosystem is damaged or disappears, it has an impact on everything else.

2.3.1. Classification of Ecosystems

- Forest, grassland, and desert are some examples of **terrestrial ecosystems**; pond, lake, wetland, river and estuary are some examples of **aquatic ecosystems**.
- Crop fields and an aquarium are human-made ecosystems.





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2.3.2. Difference Between Ecology, Environment, Habitat & Ecosystem

- **Ecology** is the **study of interactions** between organisms, organisms and the surroundings occurring within an ecosystem or environment.
  An ecosystem is a **functional unit of the environment (mostly the biosphere)**.
- An environment is a **group of ecosystems**.
- A habitat is a **part of the ecosystem.**

Q. Which one of the following is the best description of the term "ecosystem"?

a) A community of organisms interacting with one another
b) That part of the earth which is inhabited by living organisms
c) A community of organisms together with the environment in which they live.
d) The flora and fauna of a geographical area.

Explanation:

- A community of organisms interacting with one another ➔ **Ecological community**.
- That part of the earth which is inhabited by living organisms ➔ **Biosphere**.
- A community of organisms together with the environment in which they live ➔ **Ecosystem**.
- The flora and fauna of a geographical area ➔ **Biodiversity**.

- **Environment** ➔ Can be almost everything or a small region.
- **Biosphere** ➔ The region on earth that supports life.
- **Habitat** ➔ Area where an organism lives.
- **Ecosystem** ➔ Producers, Consumers, Decomposers, and their relationships (tiny environment). It is the **functional unit of the environment**.
- **Ecology** ➔ Study of interactions in an ecosystem

Answer: c)

2.4. Components of an Ecosystem

- The components of the ecosystem are categorized into abiotic or non-living and biotic or living components. Both the components of the ecosystem and environment are the same.

2.4.1. Abiotic Components

- Abiotic components are the inorganic and non-living parts that act as major **limiting factors**.
- A lot of factors determine the survival of an organism. But **one single factor can limit the range of an organism**. This single factor is called a **limiting factor**.
- For example, **seeds do not germinate quickly in evergreen rain forests** despite good rains & luxuriant vegetation.
- This is because the surface soil is **heavily leached** (nutrients washed away) by running water.
- Here, the inferior surface soil is the limiting factor that limits the germination of seeds.
- Likewise, **germinated saplings may not survive due to lack of light** because of the **dense canopy**. Here, the absence of light (shade of the forest) is the limiting factor.

Q. If a tropical rain forest is removed, it does not regenerate quickly as compared to a tropical deciduous forest. This is because

a) the soil of rain forest is deficient in nutrients
b) propagules of the trees in a rain forest have poor viability

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c) the rain forest species are slow-growing
d) exotic species invade the fertile soil of rain forest.

Explanation:

- The soil of rain forest is deficient in nutrients (true): Rainforest ⇒ It rains almost every day ⇒ The topsoil is continuously washed away ⇒ nutrients are also washed away **(leaching of nutrients**) ⇒ very little fertility remains in topsoil ⇒ most of the seeds don't germinate for years ⇒ regeneration of a rainforest is very slow (it takes decades).
- But the layer below the topsoil (sub-soil) is very fertile. Thus, plants proliferate once their roots reach the sub-soil and if they receive enough sunlight.
- Propagules of the trees in a rain forest have poor viability (true): **Propagule** ⇒ detachable structure that can give rise to a new plant, e.g., a bud, sucker, or spore (sexual reproduction in plants). However, **seed-bearing plants (spermatophytes) are more significant than propagules in a rainforest**.
- The rainforest species are slow-growing (false): The plant species in rainforests **compete for sunlight**. Hence, they grow as rapidly as they can.
- Exotic species (non-native) invade the fertile soil of rain forest: this statement is wrong as the rainforest soil is heavily leached. Hence, they are not fertile. But exotic invasive species are a threat to the rainforests, especially when the forests are cleared.

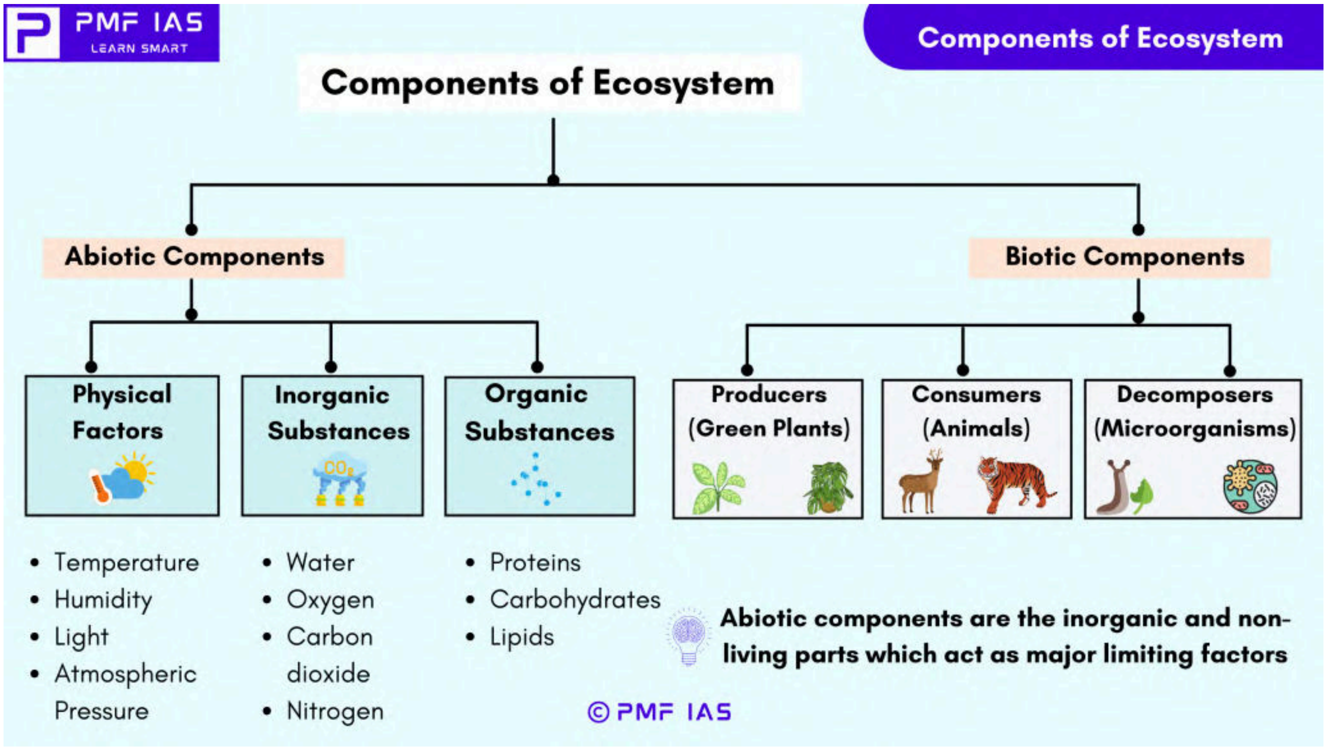
Answer: a)

Major Limiting Factors

Light

- The spectral quality of solar radiation is essential for life.
- The UV component of the spectrum is harmful to many organisms.

Rainfall



- The majority of biochemical reactions take place in an aqueous medium.

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Temperature

- A few organisms can tolerate and thrive in a wide range of temperatures (they are called **eurythermal**).
- A vast majority of them are restricted to a narrow range of temperatures (**stenothermal**).

Atmosphere

- 21% oxygen helps in the survival of many organisms, **78% nitrogen prevents spontaneous combustion**, and 0.038% carbon dioxide helps primary producers synthesize **carbohydrates**.

Organic compounds

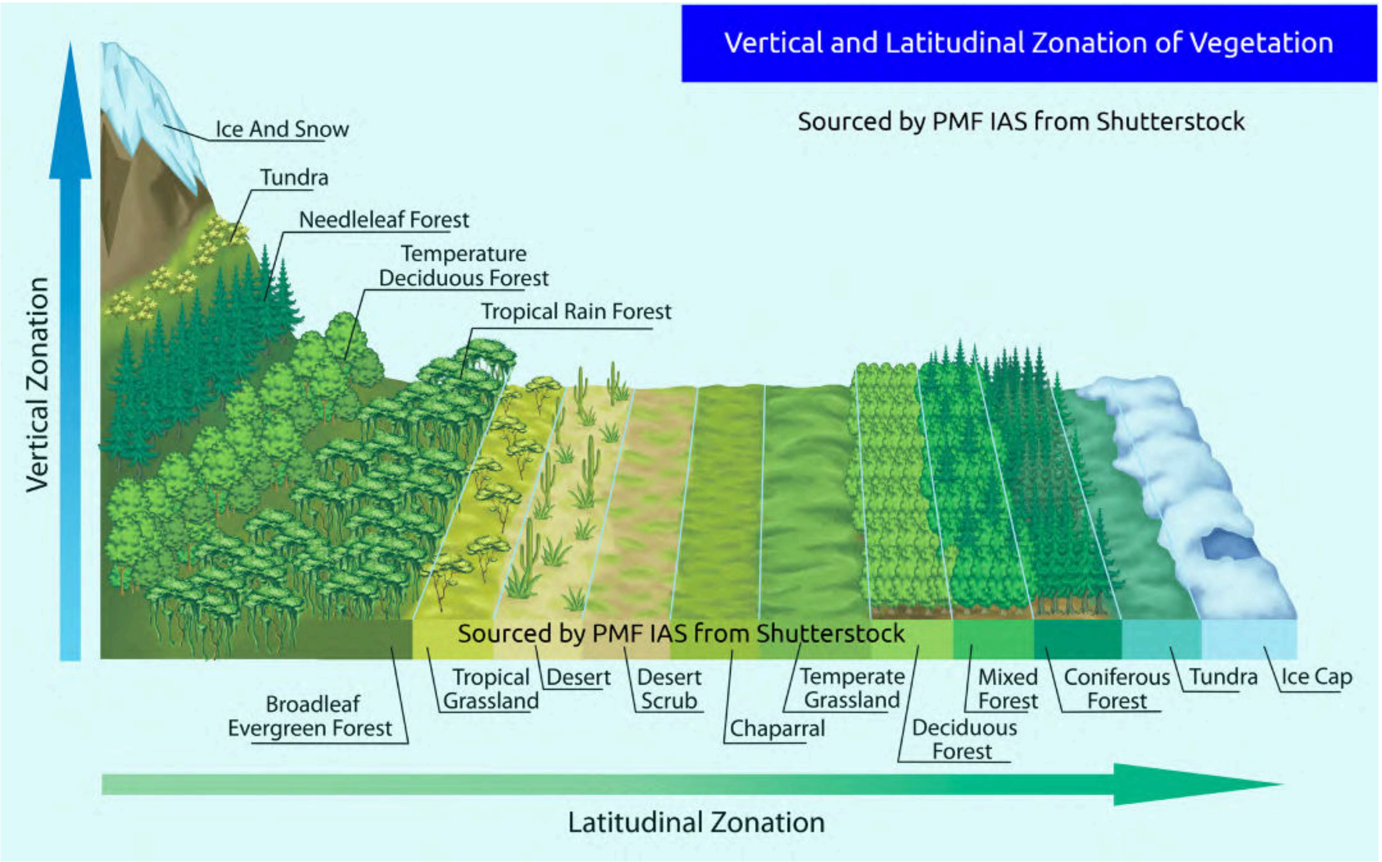
- **Proteins, carbohydrates, lipids** etc., are essential for energy transfer in the living world.

Inorganic compounds

- **Carbon, carbon dioxide, water, sulphur, nitrates, phosphates**, and ions of various metals are essential for organisms to survive.

Altitude

- **Vertical zonation of vegetation** is caused due to altitude.
- Change in temperature with altitude is a limiting factor.



Buffering capacity of the earth

- A **neutral pH (pH of 7)** is maintained in the soil and water bodies due to the buffering capacity of earth.
- The neutral pH is conducive for the survival and sustenance of living organisms.

Salinity

- Some organisms are tolerant of a wide range of salinities (**euryhaline**).

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- Others are restricted to a narrow range of salinities (**stenohaline**).

2.4.2. Effect of Abiotic Components on Terrestrial Primary Producers (Plants)

Light

- **Extremely high intensity favours root growth than shoot growth** which results in **increased transpiration, short stem, smaller, thicker leaves**.
- On the other hand, **low intensity of light retards growth**, flowering, and fruiting.
- When the intensity of light is less than the minimum, the plants cease to grow due to the **accumulation of CO_2** and finally die. Of the visible part of the spectrum, **only red and blue are effective in photosynthesis**.
- **Plants grown in blue light are small; red light results in elongation of cells (etiolated plants)**.
- **Plants grown in ultraviolet and violet light are dwarf**.

Frost

- Frost results in **freezing the soil moisture**.
- The plants are **killed due to increased transpiration when their roots are unable to supply moisture**.
- Water in the intercellular spaces of the plant gets frozen into ice. This results in **increased concentration of salts and dehydration of cells**.
- Also, frost leads to canker formation (various plant diseases with similar symptoms caused by a wide range of fungi, bacteria, and viruses).

Snow

- Snow acts as a blanket, prevents a further drop in temperature and **protects seedlings from excessive cold and frost**.
- Accumulation of snow on tree parts can break the branches or even uproot the tree.
- Snow shortens the period of vegetative growth.

Temperature

- High-temperature results in the death of plants due to **coagulation of protoplasmic proteins** (some bacteria can survive high temperatures because of their **protoplasmic proteins that do not coagulate at normally high temperatures**).
- High temperature disturbs the balance between respiration and photosynthesis.
- It also results in desiccation of plant tissues and depletion of moisture.

Dieback

- It refers to the progressive dying, usually backwards **from the tip** of any portion of the plant.
- This is one of the **adaptive mechanisms** to avoid adverse conditions like drought.
- In this mechanism, the **root remains alive** for years together, but the shoots die.
- E.g. sal, red sanders, silk-cotton tree etc.

2.4.3. Biotic Components

Primary Producers or Autotrophs (Self-Nourishing)

- Primary producers are green plants, certain bacteria and **cyanobacteria or blue-green algae** that carry out **photosynthesis**.
- In the aquatic ecosystem, **microscopic algae (plankton)** are the primary producers.

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Consumers or Heterotrophs or Phagotrophs (Other Nourishing)

- Consumers are incapable of producing their own food.
- They depend on organic food derived from plants, animals or both.
- Consumers can be divided into two broad groups, namely micro and macro consumers.

Macro Consumers

- **Herbivores** are **primary consumers** that feed mainly on plants. E.g., sheep, rabbit, etc.
- **Secondary consumers** feed on primary consumers. E.g., wolves, dogs, snakes, etc.
- **Carnivores** that feed on both primary and secondary consumers are called **tertiary consumers**. E.g., lions (can eat wolves), snakes etc.
- **Omnivores** are organisms that consume both plants and animals. E.g., man, bear, **pig**, etc.

Micro Consumers or Saprotrophs (Decomposers or Osmotrophs)

- They are **bacteria and fungi (e.g., mushrooms)** which obtain energy and nutrients from dead organic substances (**detritus**).
- **Earthworms** and certain soil organisms (such as **nematodes** and **arthropods**) are detritus feeders and help decompose organic matter and are called **detrivores**.

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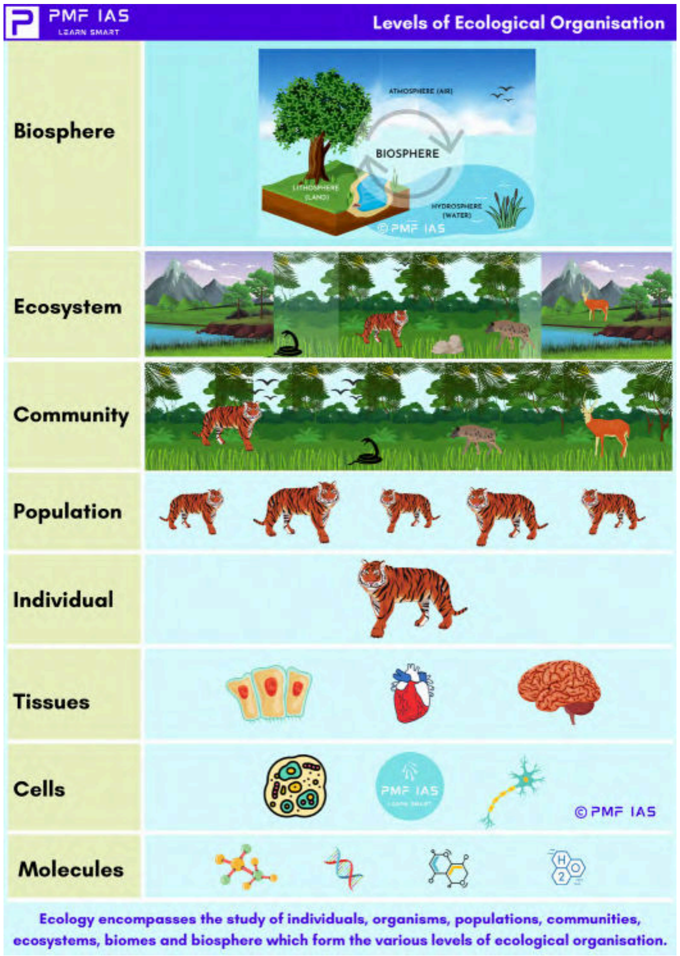
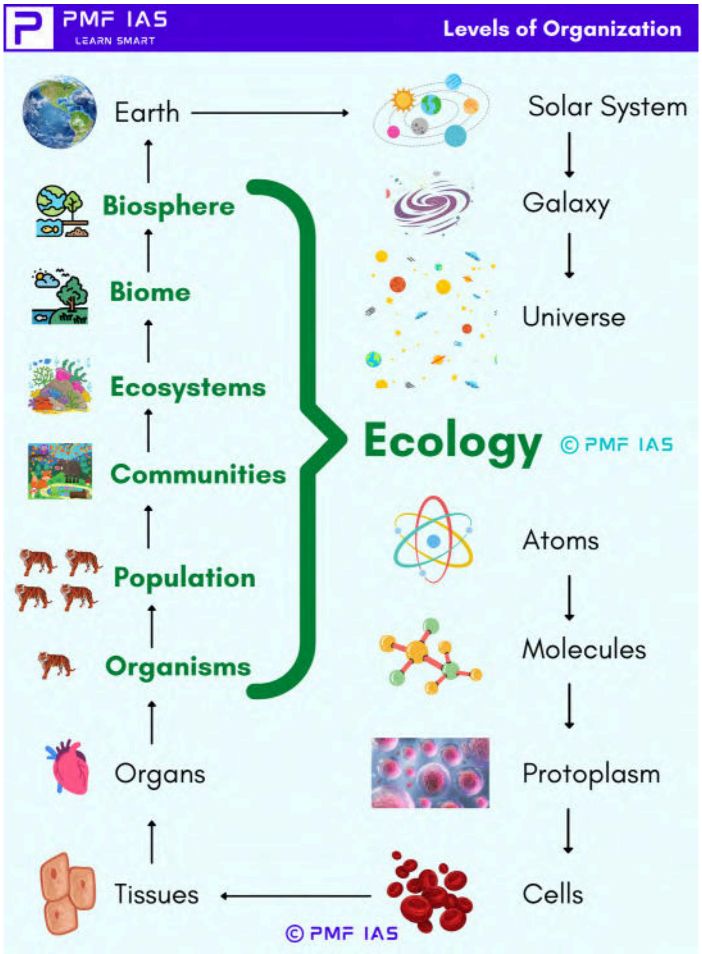
3. Ecology – Principles and Organizations

- The term ecology was derived from two Greek words, 'Oikos' meaning home and 'logos' meaning study.
- **Ecology** is the branch of biology concerned with the **relations of organisms to one another** (energy flow and mineral cycling) and **their physical surroundings** (environment).

3.1. Levels of Organizations in Ecology

- Ecology encompasses the study of **individual, organisms, population, community, ecosystem, biome and biosphere,** which form the various levels of ecological organization.





3.1.1. Individual and Species

- An organism is an individual living being that can act or function independently.
- Species are a group of living organisms consisting of **similar individuals capable of exchanging genes or of interbreeding**.
- They are considered the **basic unit of taxonomy** and are denoted by a Latin binomial, e.g., *Homo sapiens*.

3.1.2. Population

- The population is a **community of interbreeding organisms** (same species) occupying a defined area during a specific time.
- Population growth rate can be positive due to birth and/or immigration or negative due to death and/or emigration.

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Identifying Populations using Pugmarks

- In large, mobile animals like tigers, leopards, lions, deer etc., the population density may be determined by counting the **pugmarks** (foot imprints) left by the animals in a defined area.
- Study of pug marks can provide the following information reliably:
  - ✓ Presence of different species in the area of study.
  - ✓ Identification of individual animals.
  - ✓ Population of large cats (tigers, lions etc.).
  - ✓ **Sex ratio and age** (young or adult) of large cats. (sex of tigers can be determined from pugmarks!)

3.1.3. Community

- Communities, in most instances, are named after the dominant plant form.
- For example, a grassland community is dominated by grasses, though it may contain herbs, trees, etc.

Major Communities

- These are large-sized and relatively independent.
- They depend only on the sun's energy from outside. E.g., **Tropical evergreen forests**.

Minor Communities

- These are dependent on neighbouring communities and are often called **societies**.
- They are secondary aggregations within a major community. E.g., A **mat of lichen on a cow dung pad**.

3.1.4. Ecosystem

- An ecosystem is a community of organisms interacting with each other and with their environment such that energy is exchanged and system-level processes, such as the **cycling of elements**, emerge.
- An ecosystem constitutes habitats of various species, usually overlapping with each other.

Ecological Niche

- Niche refers to the **unique functional role and position of a species in its habitat or ecosystem**.
- The functional characteristics of a species in its habitat is referred to as "**niche**" in that common habitat.
- In nature, many species occupy the same habitat, but they perform different functions:
  a) **habitat niche** – where it lives, food niche – what it eats or decomposes & what species it competes with,
  b) **reproductive niche** – how and when it reproduces,
  c) **physical & chemical niche** – temperature, land shape, land slope, humidity & another requirement.
- Niche plays an essential role in the **conservation of organisms**. If we have to conserve species in their native habitat, we should know the **niche requirements of the species**.

Difference Between Niche and Habitat

- The habitat of a species is like its 'address' (i.e., where it lives), whereas niche can be thought of as its "lifestyle & profession" (i.e., activities and responses specific to the species).
- **A niche is unique for a species while many species share the habitat**.
- **No two species in a habitat can have the same niche**. This is because of the **competition with one another until one is displaced**.
- For example, many different species of insects may be pests of the same plant, but they can co-exist as they feed on different parts of the same plant.

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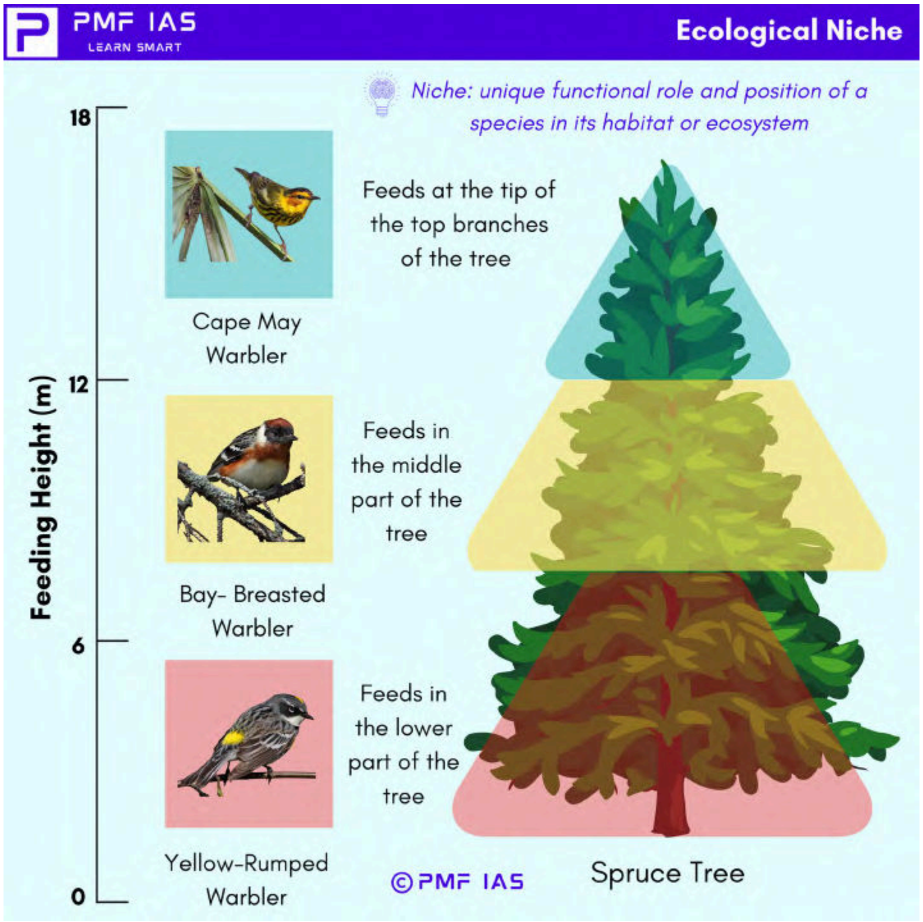

Q. Which one of the following terms describes not only the physical space occupied by an organism but also its functional role in the community of organisms?

a) Ecotone
b) Ecological niche
c) Habitat
d) Home range

Explanation:

- **Ecotone ➔** zone of transition between two ecosystems. E.g., grasslands, mangroves etc.
- **Habitat ➔** surroundings in which an organism lives (home).
- **Home Range ➔** A home range is an area where an animal lives and moves on a daily or periodic basis (a little bigger than habitat – home → office → home).

Answer: b) Niche

3.1.5. Biome

- A biome is a **large, naturally occurring community of flora and fauna occupying a major habitat**.
- E.g., Rainforest biome or tundra biome.
- Plants and animals in a biome have **common characteristics due to similar climates** and **can be found over a range of continents**.
- **Biomes are distinct from habitats** because any **biome can comprise a variety of habitats**.

Ecotone

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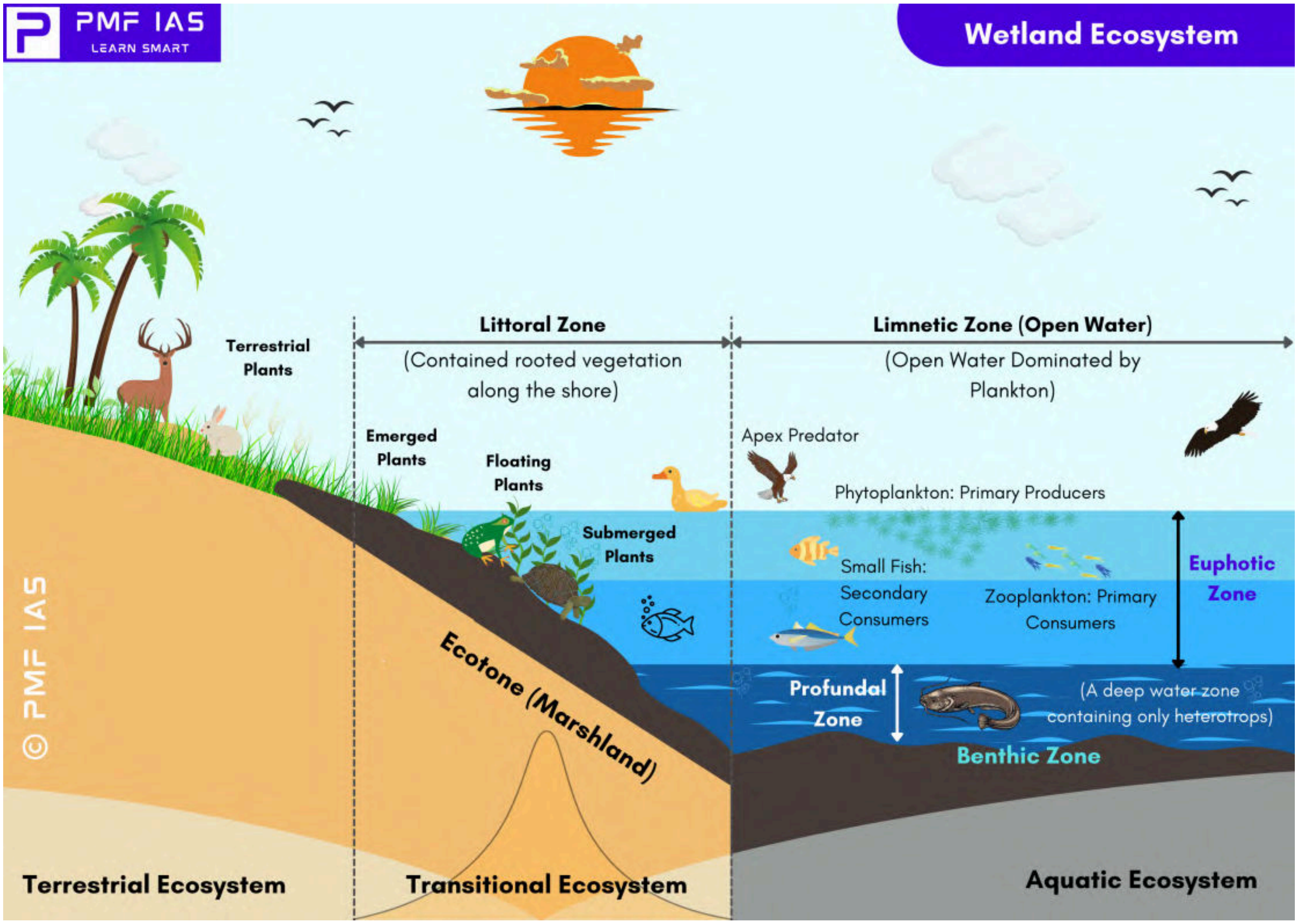
- An ecotone is a **zone of junction or a transition** area between two biomes (diverse ecosystems).
- Ecotone is the zone where two communities meet and integrate.
- E.g. the **mangrove forests** represent an ecotone between **marine** and **terrestrial ecosystems**.
- Other examples are **grassland** (between forest and desert), **estuarine** (between fresh water and salt water) and **riverbank or marshland** (between dry and wet).

Characteristics of Ecotone

- It may be **narrow (between grassland and forest)** or **wide (between forest and desert)**.
- It has **conditions intermediate** to the adjacent ecosystems. Hence it is a **zone of tension**.
- Usually, the number and the population density of the species of an outgoing community decreases as we move away from the community or ecosystem.
- A well-developed ecotone contains some organisms which are entirely different from that of the adjoining communities.
- **Ecotone regions (transitional zones)** like **mangroves, wetlands, estuaries, grasslands** etc., **have far greater productivity than natural ecosystems** like a forest ecosystem, ocean ecosystem, pond ecosystem, riverine ecosystem, desert ecosystem etc.
- This is because of the **wide-ranging species from the adjacent ecosystems** being present in the ecotone.



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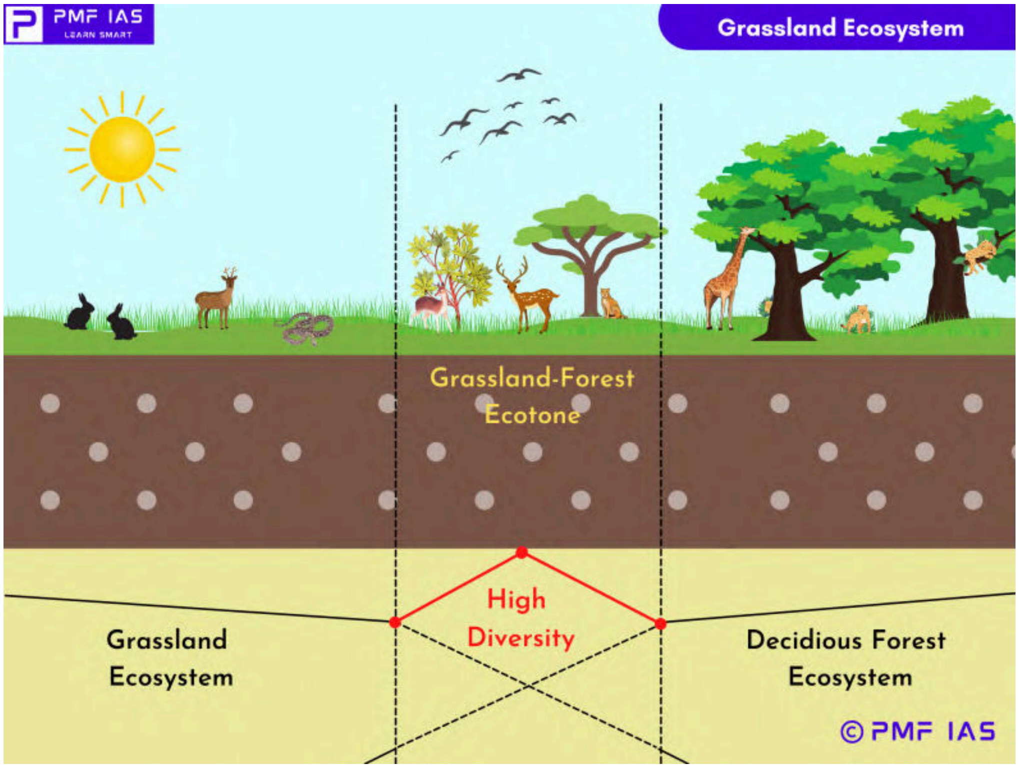


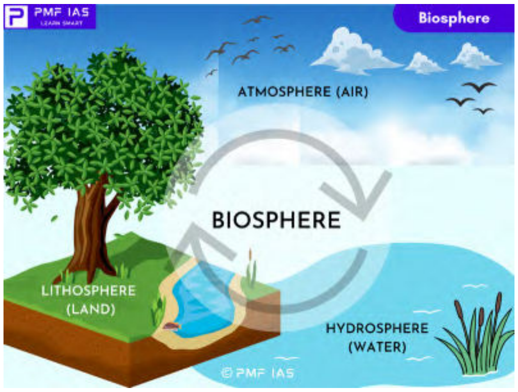
Ecocline

- **Ecocline is a zone of gradual but continuous change from one ecosystem to another** when there is no sharp boundary between the two in terms of species composition.
- Ecocline occurs across the environmental gradient (gradual change in abiotic factors such as altitude, temperature (thermocline), salinity (halocline), depth, etc.).

Edge Effect – Edge Species

- Edge effect refers to the **changes in population or community** structures **at the boundary of two habitats (ecotone)**.
- Sometimes the **number of species and the population density of some of the species in the ecotone is much greater than either community**. This is called the **edge effect**.
- The organisms which occur primarily or most abundantly in this zone are known as **edge species**.
- In terrestrial ecosystems edge effect is especially applicable to **birds**.
- For example, the **density of birds is greater in the ecotone** between the forest and the desert.

3.1.6. Biosphere



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- The biosphere is the biological component (supporting life) of the earth which includes the lithosphere, hydrosphere and atmosphere.
- The biosphere includes all living organisms, together with the dead organic matter produced by them.
- The biosphere is **absent at extremes** of the North and South poles, the highest mountains and the deepest oceans since existing hostile conditions there do not support life (**life is the characteristic feature of the biosphere**).
- Occasionally, **spores of fungi and bacteria** do occur at great height beyond 8,000 metres, but they are metabolically inactive and hence represent only **dormant life**.

3.2. Principles of Ecology

3.2.1. Adaptation

- An adaptation is "the appearance / behaviour / structure / mode of life of an organism that **allows it to survive in a particular environment**".

Adaptation may be:

1. **Morphological** – when trees grew higher, the giraffe's neck got longer.
2. **Physiological** – in the absence of an external source of water, the kangaroo rat in North American deserts can meet all its water requirements through **internal fat oxidation** (in which water is a by-product). It also has the ability to concentrate its urine so that a minimal volume of water is used to remove excretory products.
3. **Behavioural** – animals migrating temporarily to a less stressful habitat.

Examples of Adaptation

Morphological

- Many desert plants have a **thick cuticle** on their leaf surfaces and have their **stomata arranged in deep pits** to **minimize water loss through transpiration**.
- Some desert plants like Opuntia **have no leaves – they are reduced to spines (to reduce transpiration)**, and the **photosynthetic function is taken over by the flattened stems** (few leaves mean less area is available for transpiration).
- Mammals from colder climates generally have **shorter ears and limbs to minimize heat loss**. (This is called **Allen's Rule**.)
- Guess **why an elephant has enormous ears? Because elephants don't sweat. They use their flapping ears to lose heat and keep the rest of the body cool**.
- A **hyperthermophile** is an organism that **thrives in extremely hot environments** — from 60 °C. E.g., **Archaebacteria** flourish in hot springs and deep-sea hydrothermal vents.

Archaebacteria (Archaea) and Eubacteria

- **Archaebacteria (ancient bacteria)** and **eubacteria (true bacteria)** are the **least organized unicellular prokaryotic** microorganisms.
- They, along with **cyanobacteria** (blue-green algae), belong to kingdom **Monera**, which contains the **least organized unicellular prokaryotic microorganisms on earth**.
- Archaebacteria **evolved separately from the bacteria and blue-green algae (cyanobacteria)**.
- **In prokaryotic cells, genetic material is not stored within a membrane-bound nucleus**.
- Instead, it is stored in a **nucleoid** that **floats in the cell's cytoplasm**.
- The main difference between archaebacteria and other groups in Monera is that archaebacteria can survive in extreme environmental conditions.
- **A special kind of protein** helps these organisms form a **protective, lipid-linked cellular membrane** – a key to withstanding ex-

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tremely **highly salty areas (halophiles)**, **hot springs & acidic habitats (thermoacidophiles)**.

Physiological

- We need to breathe faster when we are in high mountains. After some days, our body adjusts to the changed conditions on the high mountain.
- Such **small changes** taking place in the body of an organism **over short periods** to overcome minor problems due to changes in the surroundings is called **acclimatization**.
- The body compensates for low oxygen availability by **increasing red blood cell production**, **decreasing the binding capacity of haemoglobin** and **increasing breathing rate**.

Behavioural

- **Desert lizards** lack the physiological ability that mammals have.
- They bask in the sun and absorb heat when their body temperature drops but move into the shade when the ambient temperature starts increasing.
- Some species are capable of burrowing into the soil to hide and escape from the above-ground heat.

3.2.2. Variation

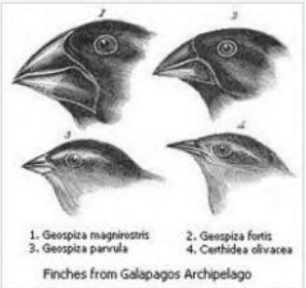
- Variations are **induced by changes in genetic makeup** due to the **addition or deletion of specific genes**.
- **Mutations, change in climate, geographical barriers** etc., induce variations over a period of time.
- The difference in the **colour of skin, type of hair, curly or straight, eye colour, blood type** among different ethnic groups represents the variation within the human species.

Adaptive radiation

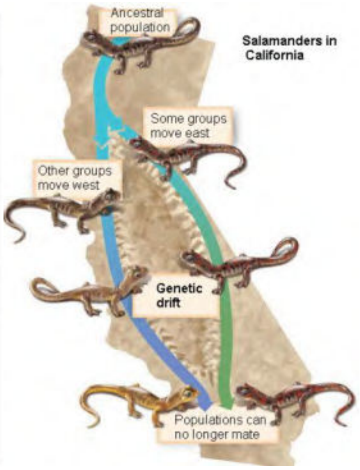
- **Adaptive radiation** is a process in which organisms **diversify from an ancestral species into a multitude of new forms** when the environment creates new challenges or opens new **environmental niches**.

3.2.3. Speciation

- **Speciation** is the process by which **new species** are formed, and **evolution** is the mechanism by which **speciation is brought about**.



Four of the 14 finch species found on the Galápagos Archipelago, are thought to have evolved by an adaptive radiation that diversified their beak shapes to adapt them to different food sources.



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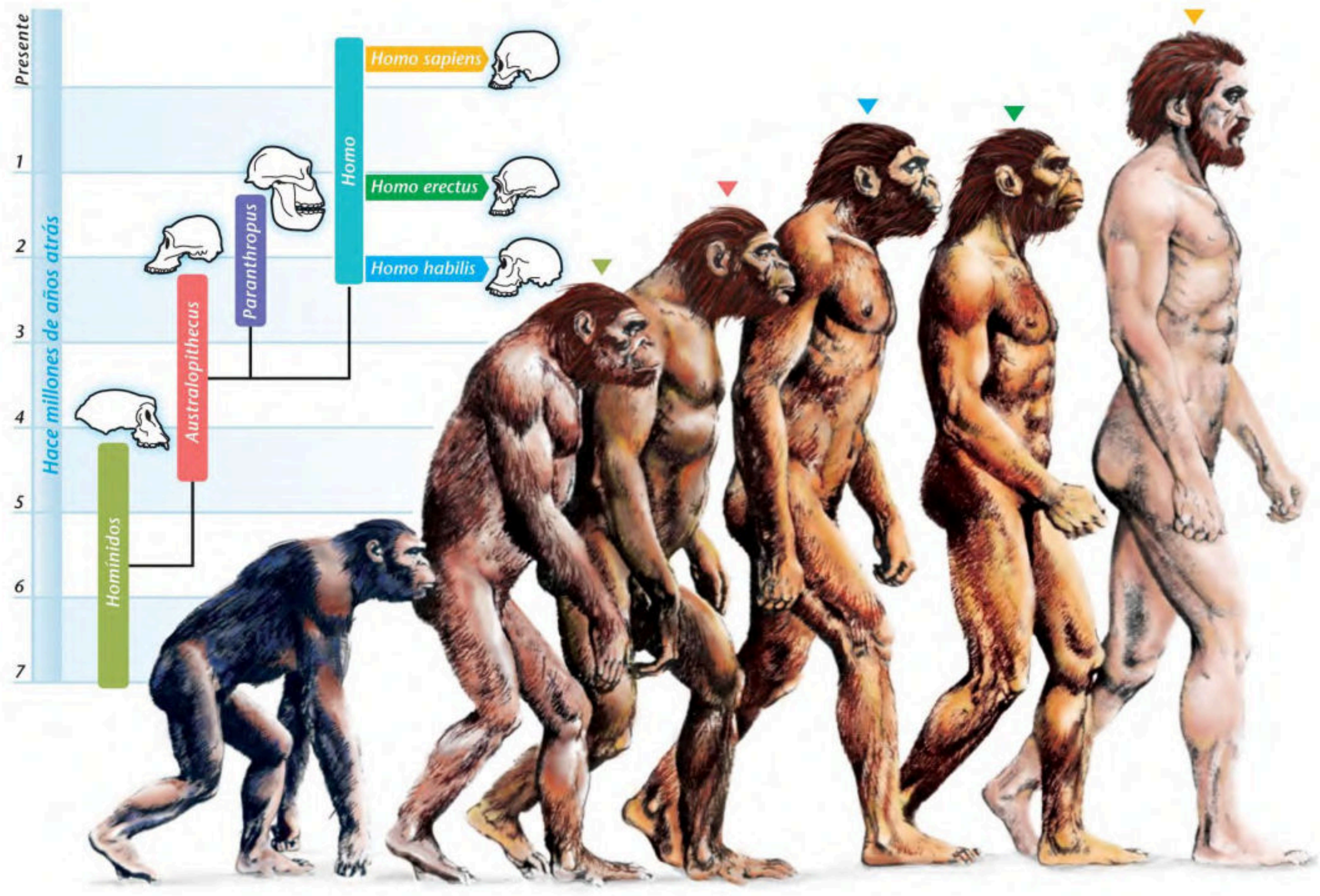

- A species comprises many populations. Often different populations of a species remain isolated due to geographic barriers such as mountains, ocean, rivers, etc.
- **Geographic isolation leads to speciation** (**allopatric speciation or geographic speciation**).
- After an extended period, the sub-populations become very different (**genetic drift**) and get isolated, reproductively, i.e., **they no longer interbreed**.
- Later even when the barrier is removed, the sub-populations are unable to interbreed, and thus subsequently, the sub-populations become two different species.

3.2.4. Mutation

- **Mutation** (**a change in genetic material** that results from an **error in replication of DNA**) causes **new genes to arise in a population**.
- Further, in a sexually reproducing population, **meiosis and fertilization** produce a **new combination of genes** every generation, which is termed **recombination**.
- **Thus, members of the same species show 'variation' and are not identical**.

3.2.5. Natural Selection

- Natural Selection is the mechanism proposed by **Darwin and Wallace**.
- Natural selection is the process by which **species adapt to their environment**.
- It is an **evolutionary force** that **selects among variations, i.e. genes that help the organism to better adapt to its environment**. Such genes are reproduced more in a population due to natural selection.

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- Those offsprings which are suited to their immediate environment have a better chance of surviving, reaching reproductive age and passing on suitable adaptations to their progeny.

3.2.6. Evolution

- **Evolution** is the **change which gives rise to new species**.
- It happens in order to make the organism better suitable to the present environment.
- **Evolution involves** the processes of **natural selection, adaptation, variation** etc.
- A valid **theory of evolution** was propounded by **Charles Darwin and Alfred Wallace in 1859**.
- This theory has been extended in the light of progress in genetics and is known as **Neo-Darwinism**.

3.2.7. Extinction

- The primary reason behind extinctions is an environmental change or biological competition.
- Extinction occurs when species cannot evolve fast enough to cope with the changing environment.
- At present, the 6th Mass Extinction (Anthropogenic Extinction – human-induced) is in progress.

Q. The term "sixth mass extinction/sixth extinction" is often mentioned in the news in the context of the discussion of (2018)

a) Widespread monoculture practices in agriculture and large-scale commercial farming with indiscriminate use of chemicals in many parts of the world that may result in the loss of good native ecosystems.
b) Fears of a possible collision of a meteorite with the earth in the near future in the manner it happened 65 million years ago that caused the mass extinction of many species including those of dinosaurs. .
c) Large scale cultivation of genetically modified crops in many parts of the world and promoting their cultivation in other parts of the world which may cause the disappearance of good native crop plants and the loss of food biodiversity.
d) Mankind's over-exploitation/misuse of natural resources, fragmentation/loss of natural habitats, destruction of ecosystems, pollution and global climate change.

Explanation: Extinction Events

1. Ordovician-Silurian Extinction (440 million years ago): Small marine organisms died out.
2. Devonian Extinction (365 million years ago): Many tropical marine species went extinct.
3. Permian-Triassic Extinction (250 million years ago): The largest mass extinction event in earth's history affected a range of species, including many vertebrates.
4. Triassic-Jurassic Extinction (210 million years ago): The extinction of other vertebrate species on land allowed dinosaurs to flourish.
5. **Cretaceous-Tertiary Extinction** (65 million Years Ago): **It wiped out dinosaurs** and some 50 per cent of plants and animals.
6. The **ongoing sixth mass extinction** is the **Anthropocene extinction (Holocene Extinction — a result of human activity)**.

Answer: d) Suggested Reading: Evolution of the Earth

Q. Which of the following are true?

1) The presence of specific features or certain habits, which enable a plant or an animal to live in its surroundings, is called evolution.
2) The surroundings where an organism lives is called its habitat.
3) Small changes that take place in the body of a single organism over short periods, to overcome small problems

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due to changes in the surroundings, is called acclimatization

4) Gradual changes in an organism to survive in an environment is call adaptation

Codes:

a) All
b) 2,3 only
c) 1,2,4 only
d) 1,2,3 only

Explanation:

- The presence of specific features or certain habits, which enable a plant or an animal to live in its surroundings, is called **adaptation** and not evolution. E.g., **Hibernation**.
- The surroundings where an organism lives is called its habitat. (True)
- Small changes that take place in the body of a single organism over short periods to overcome minor problems due to changes in the surroundings is called **acclimatization** (True). E.g., **Soldiers undergo rigorous acclimatization training** before they can serve in harsh climatic regions like **Siachen Glacier**.
- **Gradual changes in an organism to survive in an environment is called evolution** and not adaptation. E.g., The evolution of the Giraffes neck over a period of time.

Answer: b) 2,3 only

Q. Choose the incorrect pairs

Characteristic feature	Vegetation
1. Sloping branches and needle-like leaves	Desert vegetation
2. Deep roots	Taiga vegetation
3. Waxy stem, thick leaves or no leaves	Tundra vegetation
4. Canopy	Tropical vegetation

Codes:

a) All
b) 4 only
c) 1,2,3 only
d) 2,3 only

Explanation:

- **Sloping branches (prevent accumulation of snow)** and **needle-like leaves (reduce transpiration) ➔ Taiga vegetation**.
- **Deep roots ➔ Desert vegetation**.
- **Waxy stem, thick leaves, or no leaves – Desert vegetation**
- **Canopy** – the characteristic feature of tropical forests – rainforests, deciduous forests etc.

Answer: c) 1,2,3 only (incorrect pairs)

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4. Functions of an Ecosystem

- The function of an ecosystem includes:
  1. **Ecological succession or ecosystem development**
  2. **Homeostasis (or cybernetic) or feedback control mechanisms**
  3. **Energy flow through the food chain**
  4. **Nutrient cycling (biogeochemical cycles)**

4.1. Ecological Succession

- The process by which communities of plant and animal species in an area are **replaced or changed** into another over a period of time is known as **ecological succession**.
- Succession is a universal process of **directional change in vegetation**, on an ecological time scale.
- Succession occurs due to large scale changes or destruction (natural or manmade).
- The process involves a progressive series of changes with one community replacing another until a **stable, mature, climax community** develops.

4.1.1. Stages in Ecological Succession

- The first plant to colonize an area is called the **pioneer community**.
- The final stage of succession is called the **climax community**.
- **A climax community is stable, mature, more complex and long-lasting**.
- The stage leading to the climax community is called **successional stages or seres**.
- Each transitional community that is formed and replaced during succession is called a **stage in succession or a seral community**.
- Succession is characterized by the following: **increased productivity, the shift of nutrients from the reservoirs, increased diversity of organisms**, and a **gradual increase in the complexity of food webs**.
- **Succession would occur faster in area existing in the middle of the large continent**.
- This is because here seeds of plants belonging to the different **seres** would reach much faster.

4.1.2. Primary Succession

- Primary succession takes place an over **where no community has existed previously**.
- Such areas include rock outcrops, newly formed deltas and sand dunes, emerging volcano islands and lava flows, glacial moraines (muddy area exposed by a retreating glacier), etc.
- In primary succession on a terrestrial site, the new site is first colonised by a few hardy **pioneer species** that are often **microbes, lichens, and mosses**.

Q. Lichens, which are capable of initiating ecological succession even on a bare rock, are actually a symbiotic association of

a) algae and bacteria
b) algae and fungi
c) bacteria and fungi
d) fungi and mosses

Explanation:

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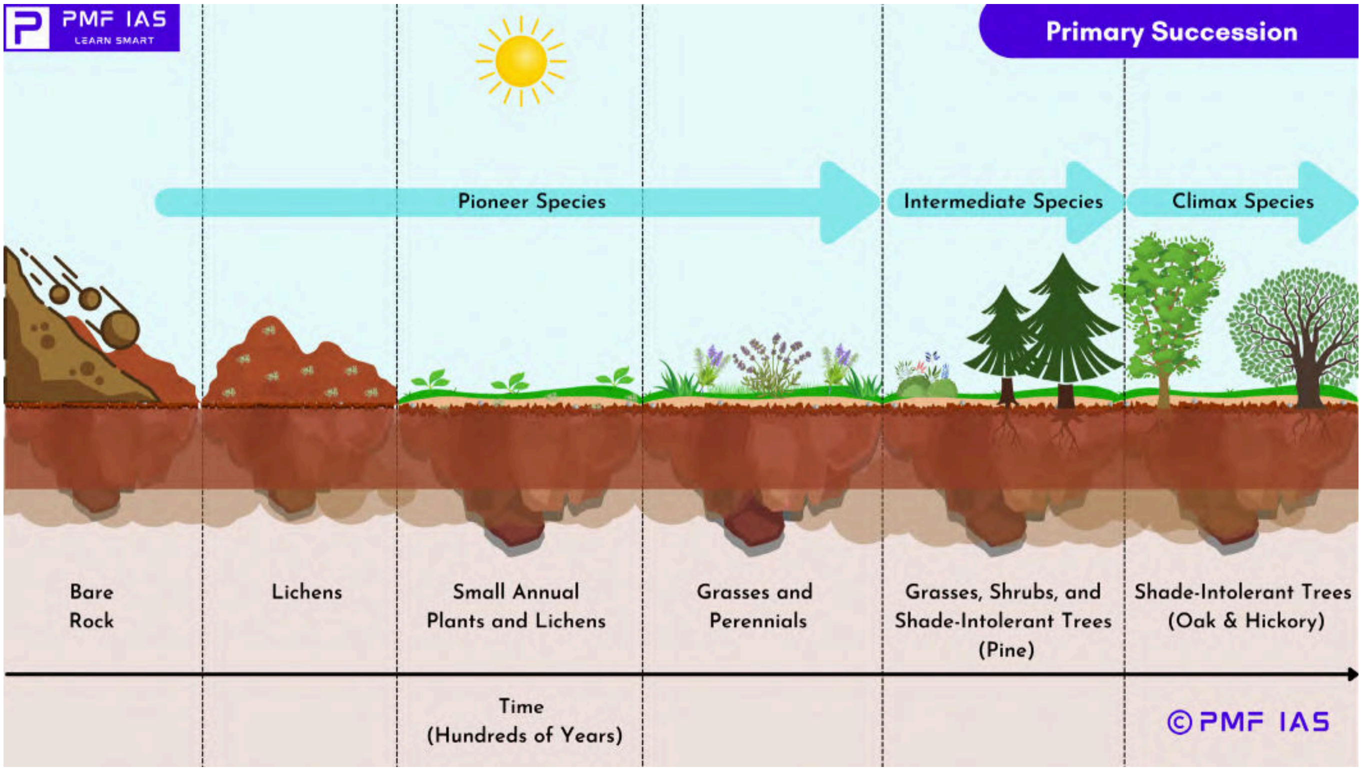
- **Lichen are plant-like organisms** that consist of a **symbiotic association of algae (usually green) or cyanobacteria and fungi**.
- Fungi provide shelter, water and minerals to the algae and, in return, the alga provides food.

Answer: b) Algae and Fungai

- The pioneers over a few generations alter the habitat conditions by their growth and development.
- The pioneers through their death any decay leave patches of organic matter in which small animals can live.
- The organic matter produced by these pioneer species produce **organic acids** during decomposition that dissolve and etch the substratum releasing nutrients to the substratum.
- Organic debris accumulates in pockets and crevices, providing soil in which seeds can become lodged and grow.
- The new conditions may be conducive to the establishment of additional organisms that may subsequently arrive at the site.
- As the community of organisms continues to develop, it becomes **more diverse, and competition increases**, but at the same time, **new niche opportunities develop**.
- The pioneer species disappear as the habitat conditions change and **invasion of new species** progresses, leading to the replacement of the preceding community.



Autotrophic and Heterotrophic succession

- Succession in which, initially the green plants are much greater in quantity is known as autotrophic succession; and the ones in which the heterotrophs are greater in quantity is known as heterotrophic succession.

4.1.3. Secondary Succession

- Secondary succession is the sequential development of biotic communities **after the complete or partial destruction of the existing community**.
- A mature or intermediate community may be destroyed by natural events such as floods, droughts, fires, or storms or by human interventions such as deforestation, agriculture, overgrazing, etc.

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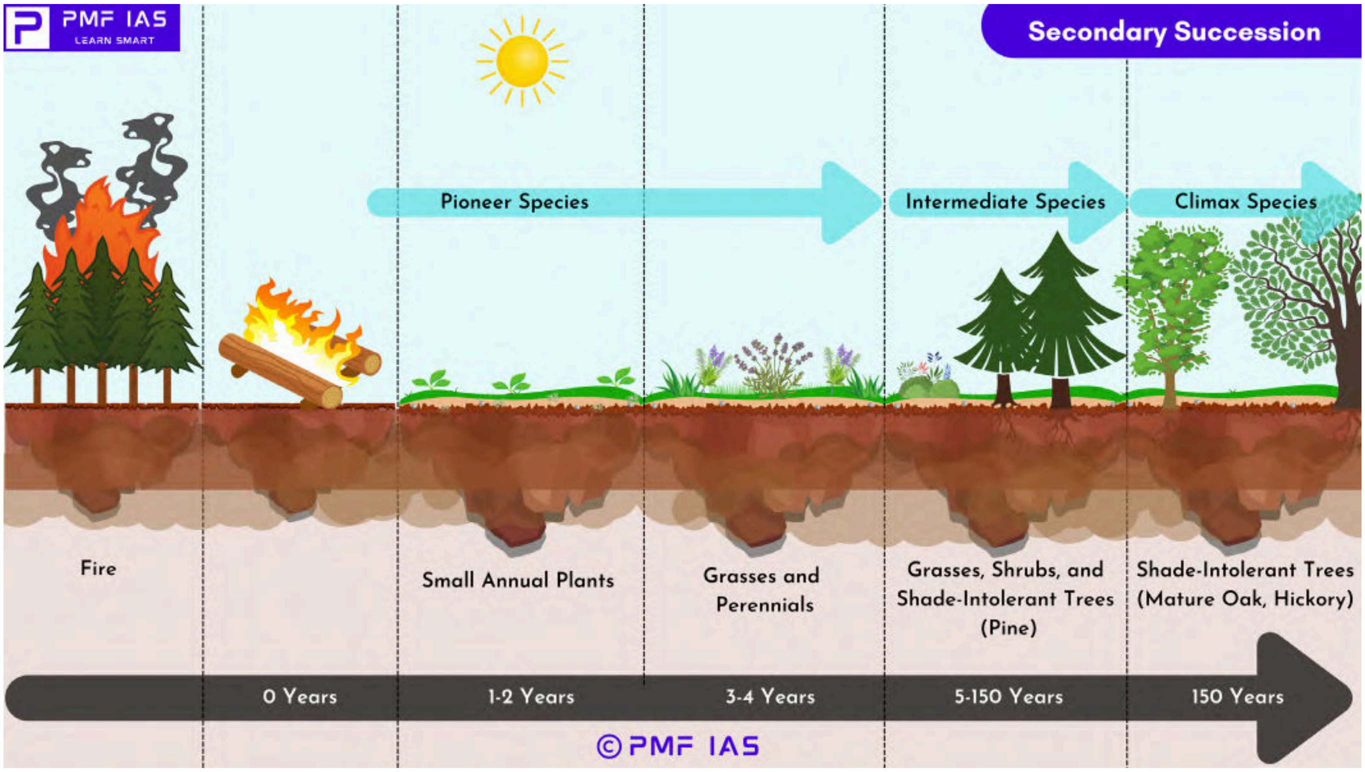
- This abandoned land is first **invaded by hardy species of grasses** that can survive in bare, sun-baked soil.
- These grasses may be soon joined by tall grasses and herbaceous plants. These dominate the ecosystem for some years along with mice, rabbits, insects, and seed-eating birds. Eventually, some trees come up in this area, seeds of which may be brought by wind or animals.
- And over the years, a forest community develops.
- Thus, an abandoned land over a period becomes dominated by trees and is **transformed into a forest**.

Difference Between Primary and Secondary Succession

- Unlike in the primary succession, the **secondary succession starts on a well-developed soil** already formed at the site. Thus, secondary succession is **relatively faster**.



4.1.4. Autogenic and Allogenic Succession

- When succession is brought about **by living inhabitants of that community itself**, the process is called **autogenic succession**, while change brought about by outside forces is known as **allogenic succession**.
- **Autogenic succession** is driven by the **biotic components** of an ecosystem.
- **Allogenic succession** is driven by the **abiotic components** (fire, flood) of the ecosystem.

Q. In the grasslands, trees do not replace the grasses as a part of an ecological succession because of

a) insects and fungi
b) limited sunlight and paucity of nutrients
c) water limits and fire
d) None of the above

Explanation:

- Grasses have one good trick to monopolise a place. In the dry season the grasses dry up and **cause fires** which destroy other plant species and their seeds (**autogenic succession**).

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- Also, grasslands develop in regions with scanty rainfall where plant growth cannot be achieved.
- Though forests form the climax community in most of the ecosystems, **in the grassland ecosystem grasses form the climax community**. Thanks to fire and lack of water.
- **Grasslands are almost irreversible** once deforestation in water-scarce areas gives way to grasslands.

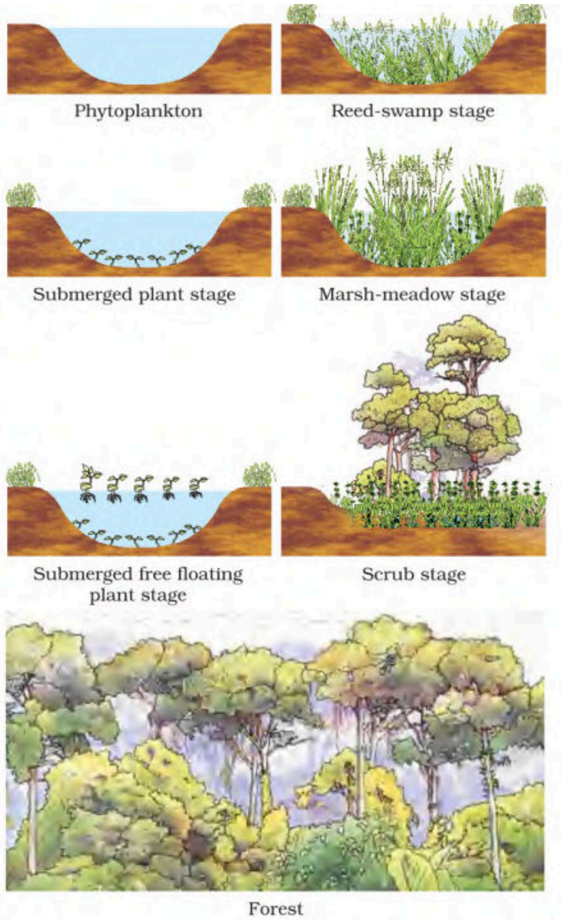
Answer: c) water limits and fire

4.1.5. Succession in Plants

- Succession that occurs on land (dry areas) where moisture content is low for e.g. on a bare rock is known as **xerarch**.
- Succession that takes place in a water body, like ponds or lake is called **hydrarch**.
- Both hydrarch and xerarch successions lead to medium water conditions (**mesic**) – neither too dry (xeric) nor too wet (hydric).
- With time the **xerophytic habitat** gets converted into a **mesophytic habitat (plat needing only a moderate amount of water)**.

4.1.6. Succession in Water

- In primary succession in water, the pioneers are the small phytoplankton, and they are replaced with time by free-floating angiosperms, then by rooted **hydrophytes (aquatic plants)**, sedges (some monocotyledonous plants), grasses and finally the trees.
- The climax again would be a forest. As the time passes, the water body is converted into land.
- Another important fact is to understand that **all succession whether taking place in water or on land, proceeds to a similar climax community – the mesic**.



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4.2. Homeostasis in Ecosystem

- In ecology, the term homeostasis applies to the **tendency for a biological system to resist changes**.
- Ecosystems can maintain their state of equilibrium.
- They can regulate their own species structure and functional processes.
- This capacity of the ecosystem of **self-regulation** is known as **homeostasis**.
- For example, in a pond ecosystem, if the population of zooplankton increases, they consume a large number of the phytoplankton and as a result, food would become scarce for zooplankton.
- When the number of zooplanktons is reduced because of starvation, the phytoplankton population start increasing.
- After some time, the population size of zooplankton also increases, and this process continues at all the **trophic levels of the food chain**.
- Note that in a homeostatic system, **negative feedback mechanism** induced by the **limiting resource** (here its scarcity of food) is responsible for maintaining stability in an ecosystem.
- However, the homeostatic capacity of ecosystems is not unlimited as well as not everything in an ecosystem is always well regulated.

4.2.1. Homeostasis

- Homeostasis is the **maintenance of stable equilibrium**, especially through physiological (through bodily part functions. E.g., Cooling your body through sweating processes.
- Organisms try to maintain the constancy of its internal environment despite varying external environmental conditions that tend to upset their homeostasis.

Regulate

- Some organisms can maintain homeostasis by physiological (sometimes behavioral — migrating to tree shade) means which ensures constant body temperature, constant osmotic concentration, etc.
- All birds and mammals and a very few lower vertebrate and invertebrate species are indeed capable of such regulation (**thermoregulation and osmoregulation**).
- **The 'success' of mammals** is largely due to their **ability to maintain constant body temperature** and thrive whether they live in Antarctica or the Sahara Desert.
- **Plants, on the other hand, do not have such mechanisms to maintain internal temperatures**.

Conform

- An overwhelming majority of animals and nearly all plants cannot maintain a constant internal environment. Their body temperature changes with the ambient temperature.
- In aquatic animals, the osmotic concentration of the body fluids changes with that of the ambient water osmotic concentration. These animals and plants are simply **conformers**.

Why had these conformers not evolved to become regulators?

- **Thermoregulation is energetically expensive** for many organisms.
- This is particularly true for small animals like shrews and hummingbirds.
- Heat loss or heat gain is a function of surface area.
- Since **small animals have a larger surface area relative to their volume**, **they tend to lose body heat very fast** when it is cold outside; then they have to expend much energy to generate body heat (a lot of food energy goes into heat generation) through metabolism.
- This is the main reason why **very small animals are rarely found in polar regions**.

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Migrate

- The organism can move away temporarily from the stressful habitat to a more hospitable area and return when a stressful period is over.
- Every winter the famous **Keoladeo National Park (Bhartpur) in Rajasthan** hosts thousands of migratory birds coming from Siberia and other extremely cold northern regions.

Suspend

- In bacteria, fungi and lower plants, various kinds of **thick-walled spores** are formed which help them to survive unfavorable conditions – these germinate on the availability of suitable environment.
- In higher plants, seeds and some other vegetative reproductive structures serve as means to tide over periods of stress besides helping in dispersal.
- In animals, the organism, if unable to migrate, might avoid the stress by escaping in time.
- The familiar case of bears going into hibernation during winter is an example of an escape in time.
- Some snails and fish go into **aestivation** to avoid summer-related problems – heat and desiccation.
- Under unfavorable conditions, many zooplankton species in lakes and ponds are known to enter **diapause, a stage of suspended development**.

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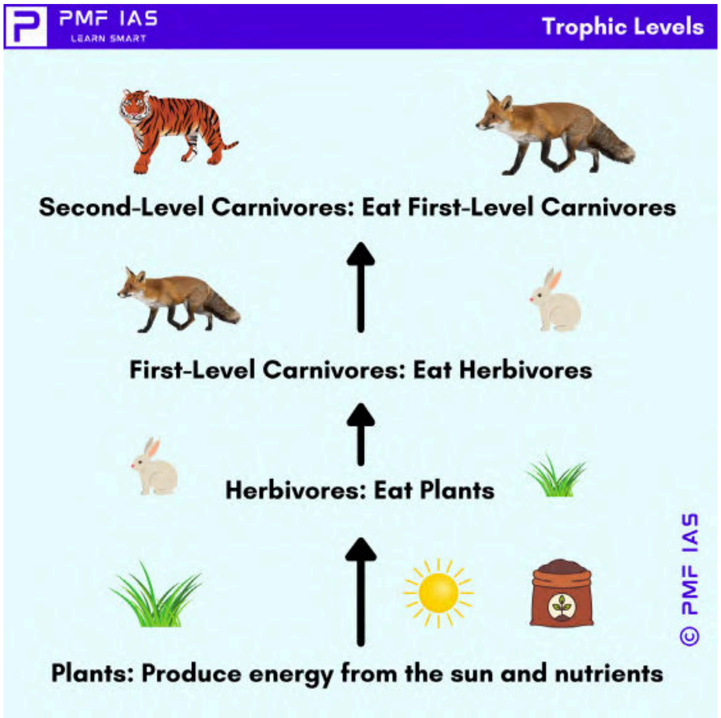
5. Energy Flow Through an Ecosystem – Trophic Levels

- A trophic level (trophe = Nourishment) is the **representation of energy flow in an ecosystem**.
- The trophic level of an organism is the position it occupies in a food chain.
- Trophic level interaction deals with how the members of an ecosystem are connected based on nutritional needs.



Trophic Levels	
Autotrophs	**Green plants (Producers)**
Heterotrophs	**Herbivore (Primary consumers)**
Heterotrophs	**Carnivores (Secondary consumers)**
Heterotrophs	**Carnivore (Tertiary consumers)**
Heterotrophs	**Top carnivores (Quaternary consumers)**

- Energy flows through the trophic levels from producers to subsequent trophic levels is **unidirectional**.
- Energy level **decreases** from the first trophic level upwards **due to loss of energy in the form of heat** at each trophic level.
- This energy loss at each trophic level is quite significant. Hence there are usually not more than four-five trophic levels (beyond this the energy available is negligible to support an organism).
- The trophic level interaction involves three concepts, namely:
  1) **Food Chain**
  2) **Food Web**
  3) **Ecological Pyramids**

5.1. Food Chain

- Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten link is called a food chain. E.g., Grasses → Grasshopper → Frog → Snake → Hawk/Eagle.
- Each step in the food chain is called **trophic level**.
- A food chain starts with producers and ends with top carnivores.

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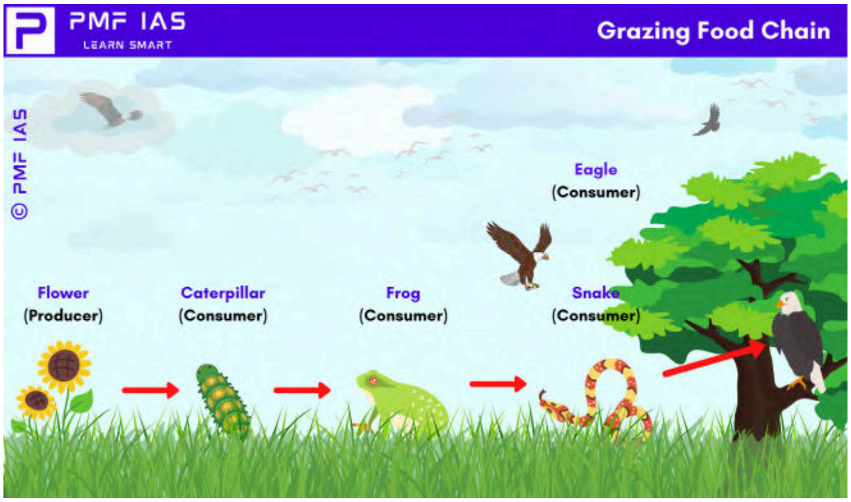
- The **trophic level of an organism** is the position it occupies in a food chain.
- Types of Food Chains: **1) Grazing food chain and 2) Detritus food chain**

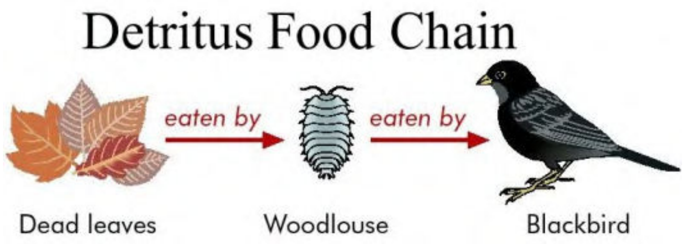
5.1.1. Grazing food chain

- The consumers which start the food chain, utilising the **plant or plant part as their food**, constitute the grazing food chain.
- For example, in a terrestrial ecosystem, the grass is eaten by a caterpillar, which is eaten by lizard and lizard is eaten by a snake.
- In Aquatic ecosystem **phytoplankton** (primary producers) are eaten by zooplanktons which are eaten by fishes and fishes are eaten by pelicans.



5.1.2. Detritus food chain

- This type of food chain **starts from organic matter** of dead and decaying animals and plant bodies from the grazing food chain.
- Dead organic matter or detritus feeding organisms are called **detrivores or decomposers**. The detrivores are eaten by predators.
- In an **aquatic ecosystem, the grazing food chain is the major conduit for energy flow**.
- As against this, in a **terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than** through the grazing food chain.



Q. With reference to the food chains in ecosystems, which of the following kinds of organism is/are known as decomposer organism/organisms?

1) Virus
2) Fungi
3) Bacteria

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Select the correct answer using the codes given below.

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- Fungi and Bacteria are decomposers. They breakdown organic matter into simple inorganic substances.
- Virus represents dormant life. They are metabolically inactive as long as they are outside a host body.
- They are not decomposers. They invade host cells and use their nucleus (DNA machinery) to carry out their life processes.
- **Protists** are unicellular organisms. **Some protists** such as paramecium and euglena **are not decomposers**.
- While the other protists like **slime moulds** typically **grow on dead animals, rotting logs & compost**.

Humus

- Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called **catabolism**.
- **Humification** and **mineralisation** occur during decomposition in the soil.
- Humification leads to accumulation of a dark-coloured amorphous (formless) substance called **humus** that is highly resistant to microbial action and **undergoes decomposition at an extremely slow rate**.
- Being **colloidal** in nature, humus serves as a **reservoir of nutrients**.
- The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as **mineralisation**.
- Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in a buildup of organic materials (**soils become acidic like in taiga**).

Answer: b) 2 and 3 only

Q. Which one of the following is the correct sequence of a food chain?

a) Diatoms-Crustaceans-Herrings
b) Crustaceans-Diatoms-Herrings
c) Diatoms-Herrings-Crustaceans
d) Crustaceans-Herrings-Diatoms

Explanation:

- The food chain starts with a producer and ends with a top consumer.
- **Phytoplankton** are the primary producers in the oceans. They include:
  - ✓ **diatoms (unicellular algae),**
  - ✓ **coccolithophores (unicellular, eukaryotic protist),**
  - ✓ **Cyanobacteria (Bluegreen algae)– Synechococcus, Prochlorococcus, Nostoc, spirogyra etc.**
  - ✓ **Dinoflagellates (flagellated protists).**
- **Crustaceans** form a large group of arthropods which includes crabs, lobsters, crayfish, shrimp, krill and barnacles (Biology NCERT).
- **Herrings** are a fish, and they eat crustaceans.

Answer: (a) Diatoms-Crustaceans-Herrings (basics are the key)

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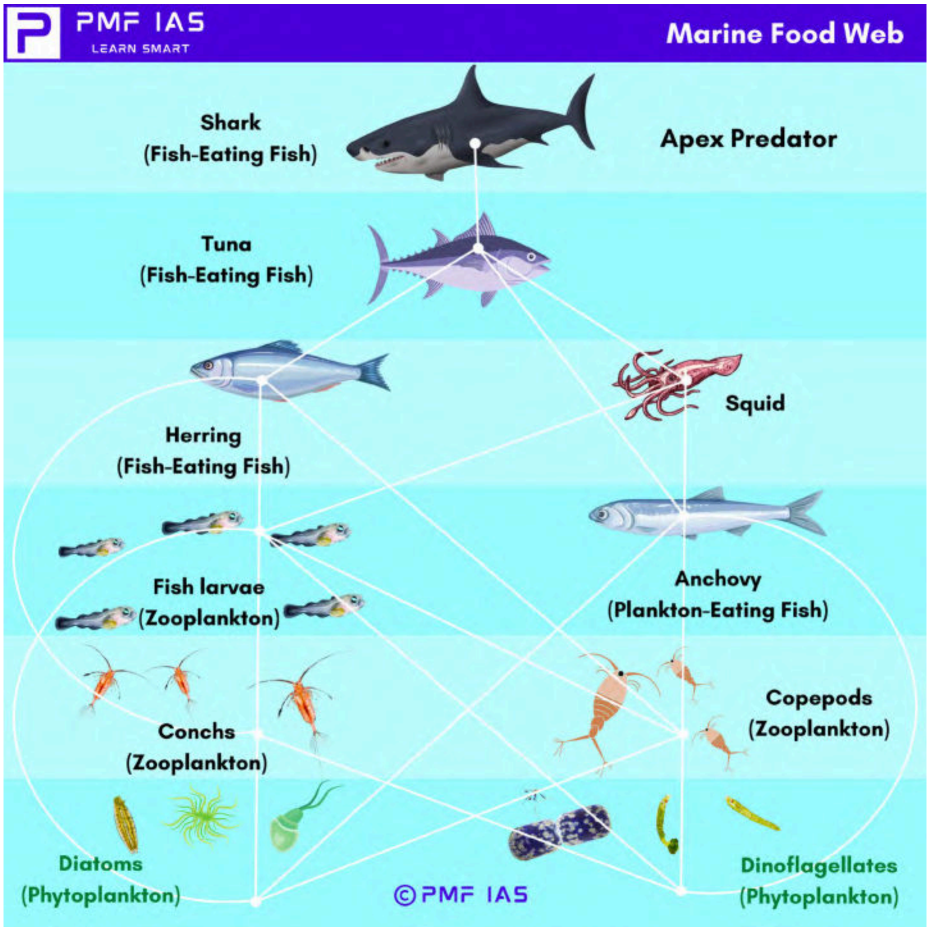
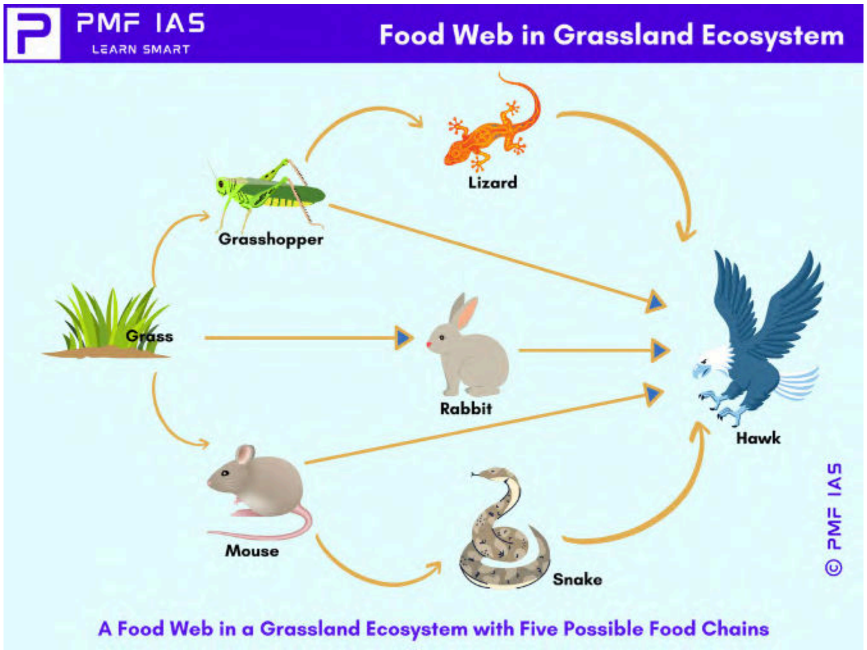
5.2. Food Web





- **Multiple interlinked food chains make a food web**.
- Food web represents all the **possible paths of energy flow** in an ecosystem.
- If any of the intermediate food chains is removed, the succeeding links of the chain will be affected largely.
- The food web provides more than one alternative for food to most of the organisms in an ecosystem and therefore increases their chance of survival.

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5.2.1. Types of Biotic Interactions in a Food Web

0 → no effect **– → is detrimental** **+ → beneficial**

Interactions	Species 1	Species 2	Effect	Comments
Negative Interactions				
Amensalism	–	0	**One species is inhibited while the other species is unaffected.**	• The bread mould fungi Penicillium produce penicillin — an antibiotic substance — which inhibits the growth of a variety of bacteria. • A large tree shades a small plant & retarding the growth of the small plant. The small plant has no effect on the large tree.
Predation	+	–	One species (predator) benefits while the second species (prey) is harmed and inhibited.	• Predators like leopards, tigers and cheetahs use speed, teeth and claws to hunt and kill their prey. • Predators help in maintaining species diversity in a community, by reducing the intensity of competition among competing prey species.
Parasitism	+	–	Beneficial to one species (parasite) and harmful to the other species (host).	• Parasitism involves parasite living in or on another living species called the host. • The parasite gets its nourishment and often shelter from its host. • Tap worm, roundworm, malarial parasite, many bacteria, fungi, and viruses are common parasites of humans. • The **female mosquito is not considered a parasite**, although it needs our blood for reproduction. Why? Because it does not live on the host.
Competition	–	–	Adversely affects both species.	• Competition occurs when two populations or species, both need a vital resource that is in short supply.
Positive Interactions				
Commensalism	+	0	**One species (the commensal) benefits, while the other species (the host) is neither harmed nor inhibited**	• **Suckerfish often attaches to a shark**. This helps the suckerfish get protection, a free ride as well as a meal from the leftover of the shark's meal. • The shark does not, however, get any benefit nor is it adversely affected by this association. • Another example of commensalisms is the **relationship between trees and epiphytic plants**.
Mutualism	+	+	Interaction is favourable to both species	• **Sea anemone gets attached to the shell of hermit crabs** for the benefit of transport and obtaining new food while the anemone provides camouflage and protection utilizing its stinging cells to the hermit crab. • Some mutualisms are so intimate that the interacting species can no longer live without each other as they depend totally on each other to survive. • Such close associations are called **symbiosis** (symbiosis is intense mutualism – E.g., **coral and zooxanthellae**).
Neutral Interactions				
Neutralism	0	0	Neither species affects the other	• True neutralism is extremely unlikely.

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Types of Biotic Interactions in a Food Web

Amensalism

It is a type of negative ecological interaction where **one of the species is harmed or destroyed while the other either benefits or remains unaffected.**

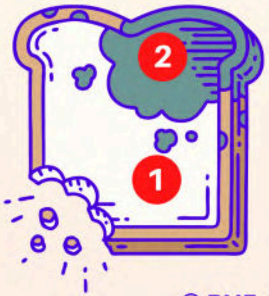
Species	
1	2
Detrimental	Zero

Antibiosis

A large tree shades a small plant & retarding the growth of the small plant. The small plant has no effect on the large tree.

Competition

The bread mould fungi Penicillium produce penicillin - an antibiotic substance which inhibits the growth of a variety of bacteria.



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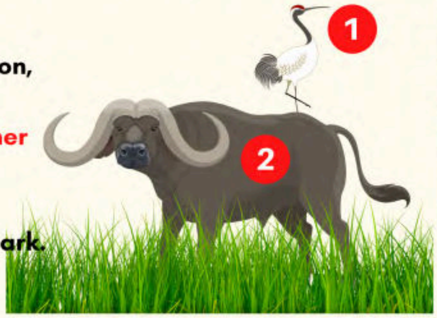
Commensalism

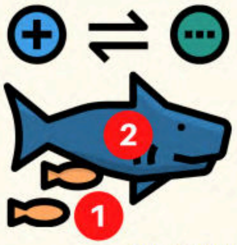
One organism benefits from the other without harming it.

Species	
1	2
Beneficial	Zero

A **Commensal species benefits from another species** by obtaining locomotion, shelter food, or support from the host species, which (for the most part) **neither benefits nor is harmed.**

1. Suckerfish often attaches to the shark.
2. Relationship between Tree and Epiphytic Plant.





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Mutualism

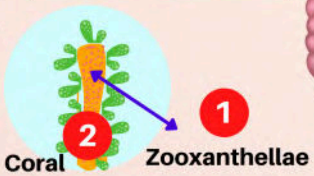
It is a type of ecological interaction between two species where **both species are benefitted from the interaction**

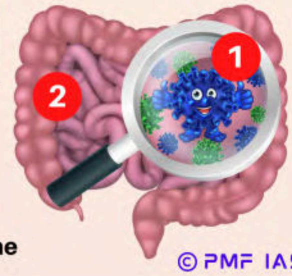
Species	
1	2
Beneficial	Beneficial

One of the species provides the other with some resource or service, and the other also reciprocates with a benefit.

Some mutualism are so intimate that the interacting species can no longer live without each other as they depend totally on each other.

Gut Microflora is one of the largest microflora in human beings. These microorganisms colonize all the parts of the digestive tract.





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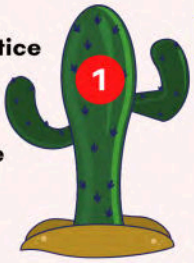
Neutralism

Neutralism describes the relationship between two species that interact but do not affect each other.

Species	
1	2
Zero	Zero

Examples of true neutralism are virtually impossible to prove; the term is in practice used to describe situations where interactions are negligible or insignificant.

Neutralism occurs when two populations interact without having an effect on the evolutionary fitness of each other. E.g. cacti and tarantulas living in the desert.



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Q. With reference to food chains in ecosystems, consider the following statements:

1) A food chain illustrates the order in which a chain of organisms feed upon each other.
2) Food chains are found within the populations of a species.
3) A food chain illustrates the numbers of each organism which are eaten by others.

Which of the statements given above is/are correct?

a) 1 only
b) 1 and 2 only
c) 1, 2 and 3
d) None

Explanation:

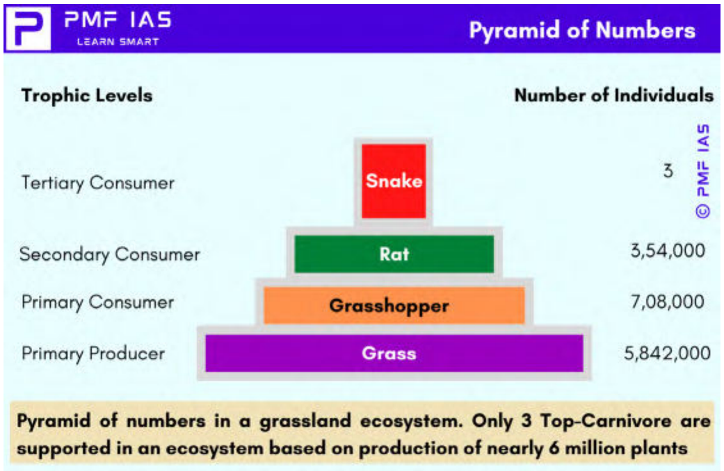
- A food chain illustrates the order in which a chain of organisms feed upon each other. (True)
- Food chains are found within the populations of a species. (Humans won't eat humans – so, false)
- A food chain illustrates the numbers of each organism which are eaten by others (food web illustrates the number, not the food chain).

Answer: a) 1 only

5.3. Ecological Pyramids

- The **pyramidal representation of trophic levels** of different organisms based on their **ecological position** (producer to final consumer) is called as an **ecological pyramid**.
- The pyramid consists of a number of horizontal bars depicting **specific trophic levels**.
- The length of each bar represents the **total number of individuals or biomass or energy** at each trophic level in an ecosystem.
- The food **producer forms the base of the pyramid**, and the top carnivore forms the tip. Other consumer trophic levels are in between.
- The ecological pyramids are of three categories:
  1) **Pyramid of numbers,**
  2) **Pyramid of biomass, and**
  3) **Pyramid of energy or productivity.**

5.3.1. Pyramid of Numbers



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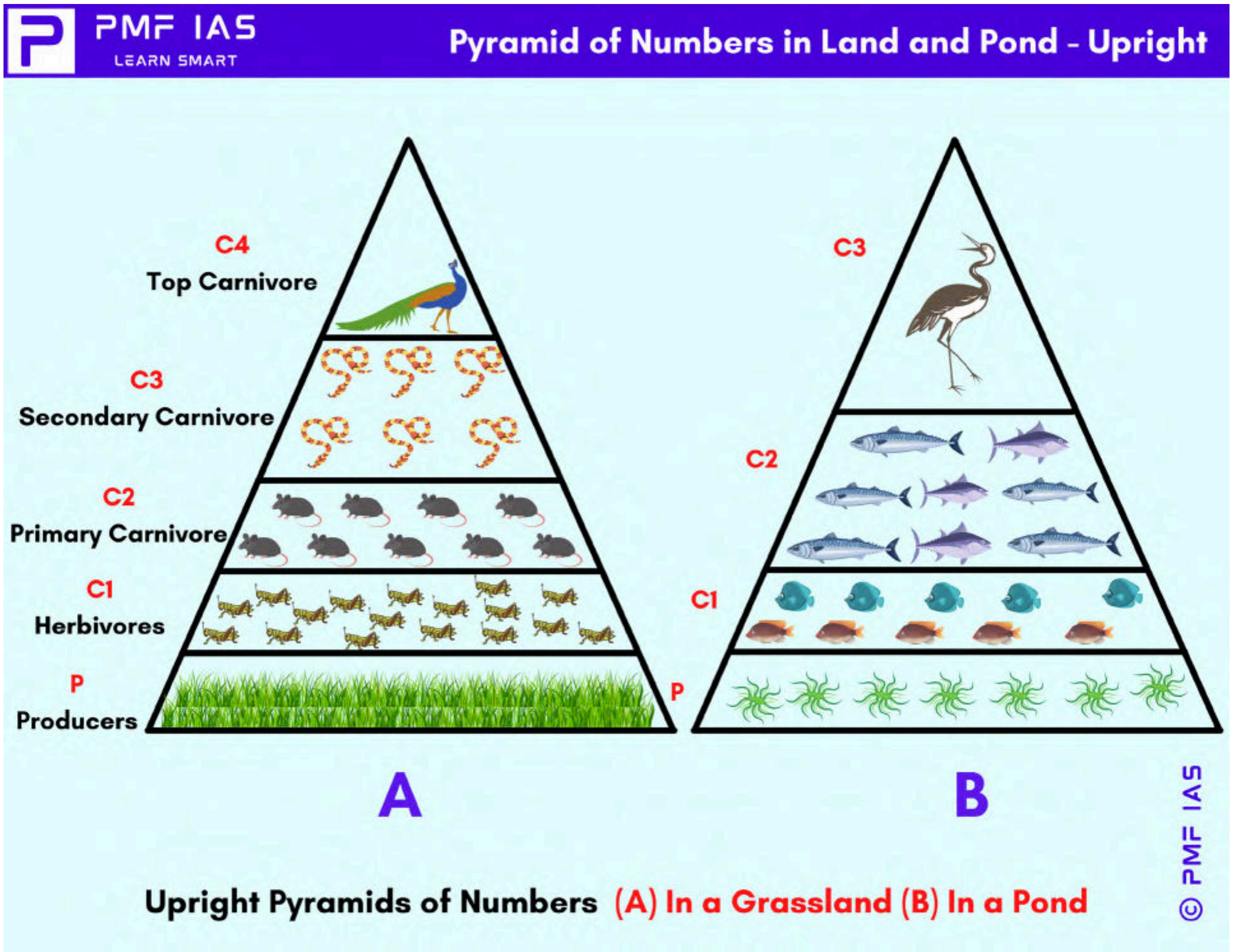
- Pyramid of numbers represents the **total number of individuals** of different species (population) at each trophic level.
- Depending upon the size, the pyramid of numbers **may not always be upright**, and **may even be completely inverted**.
- It is very difficult to count all the organisms in a pyramid of numbers and so the **pyramid of number does not completely define the trophic structure** for an ecosystem.

Pyramid of Numbers – Upright

- In this pyramid, the number of individuals is decreased from lower level to higher trophic level.
- This type of pyramid can be seen in the **grassland ecosystem** and **pond ecosystem**.



- The grasses occupy the lowest trophic level (base) because of their abundance.
- The next higher trophic level is primary consumer – herbivores like a grasshopper.
- The individual number of grasshoppers is less than that of grass.
- The next energy level is a primary carnivore like rats.
- The number of rats is less than grasshoppers, because they feed on grasshoppers.
- The next higher trophic level is secondary carnivore like snakes. They feed on rats.
- The next higher trophic level is the top carnivore like Hawk.
- With each higher trophic level, the number of individual decreases.

Pyramid of Numbers – Inverted

- In this pyramid, the number of individuals is increased from lower level to higher trophic level. E.g., **Tree ecosystem**.

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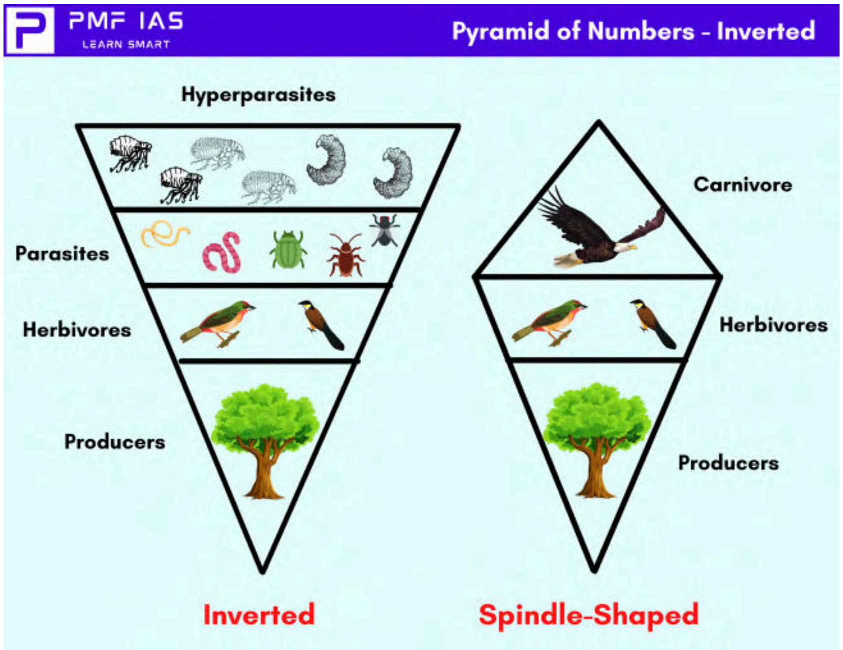
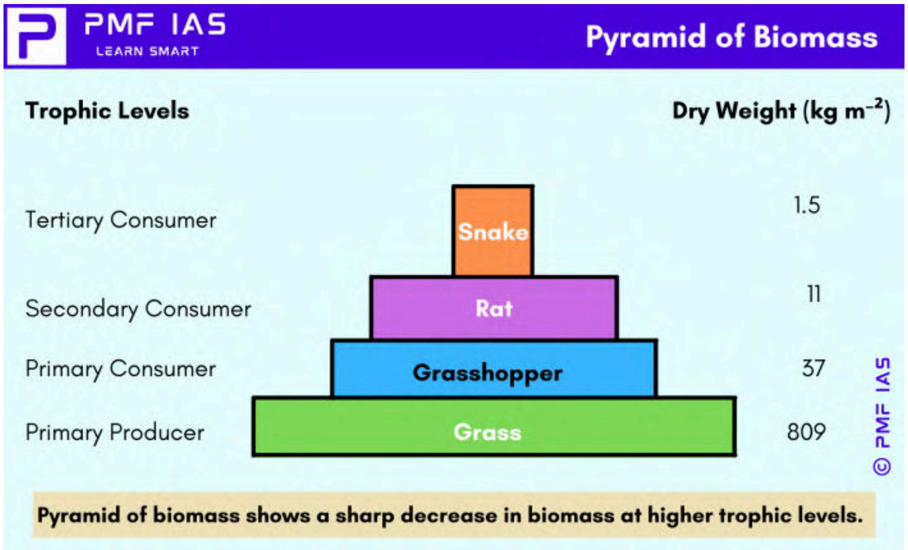


5.3.2. Pyramid of Biomass

- Pyramid of biomass is usually determined by collecting all organisms occupying each trophic level separately and measuring their **dry weight**.
- This overcomes the size difference problem because all kinds of organisms at a trophic level are weighed.
- Each trophic level has a certain mass of living material at a particular time called the **standing crop**.
- The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area.



Pyramid of Biomass – Upright

- For **most ecosystems on land**, the pyramid of biomass has a large base of primary producers with a smaller trophic level perched on top.
- The biomass of producers (autotrophs) is at the maximum.
- The biomass of next trophic level i.e. primary consumers is less than the producers.
- The biomass of next higher trophic level i.e. secondary consumers is less than the primary consumers.
- The top, high trophic level has very less amount of biomass.

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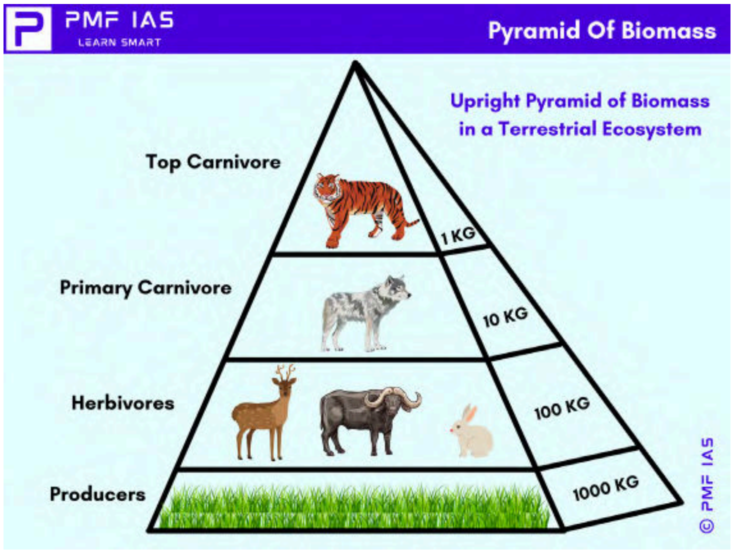
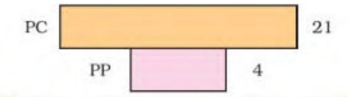
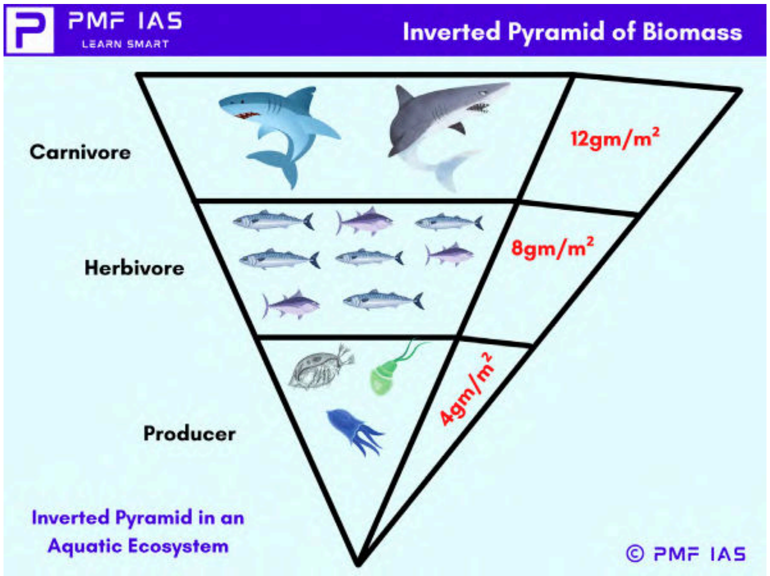


Pyramid of Biomass – Inverted



Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton

- In contrast to terrestrial ecosystems, in many **aquatic ecosystems**, the **pyramid of biomass may assume an inverted form**. (**In contrast, a pyramid of numbers for the aquatic ecosystem is upright**)
- This is because the producers are **tiny phytoplankton** that grows and reproduces rapidly.
- Here, the pyramid of biomass has a small base, with the **consumer biomass at any instant exceeding the producer biomass** and the pyramid assumes an inverted shape.



5.3.3. Pyramid of Energy

- **Energy pyramid is most suitable** to compare the **functional roles of the trophic levels** in an ecosystem.
- An energy pyramid represents the **amount of energy at each trophic level and loss of energy at each transfer to another trophic level**.
- Hence **the pyramid is always upward**, with a large energy base at the bottom.

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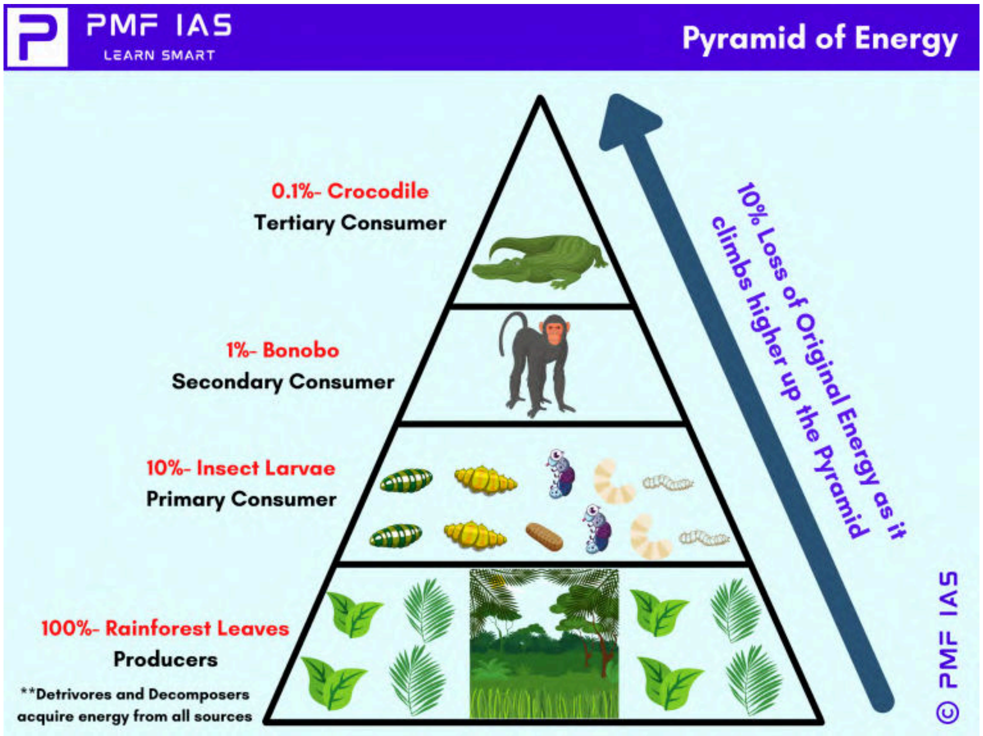

- Suppose an ecosystem receives 1000 calories of light energy on a particular day, most of the energy is not absorbed. Some of it is reflected to space.
- Of the energy absorbed only a small portion is utilized by green plants, out of which the plant uses up some for respiration; therefore only 100 calories are stored as energy-rich materials.
- Now suppose an animal, say a deer, eats the plant containing 100 calories of food energy. The deer use some of it for its **metabolism** and stores only 10 calories as food energy.
- A lion that eats the deer gets an even smaller amount of energy.
- Thus, usable energy decreases from sunlight to producer to herbivore to carnivore.
- Therefore, the **energy pyramid will always be upright**.
- Energy pyramid concept helps to explain the phenomenon of **biological magnification** — the tendency for toxic substances to **increase in concentration** progressively **with higher trophic levels**.

Ecological Efficiency

- **Ecological efficiency** describes the efficiency with which energy is transferred from one trophic level to the next.
- The number of trophic levels in the **grazing food chain** is restricted as the transfer of energy follows **10 per cent law** — only 10 per cent of the energy is transferred to each trophic level from the lower trophic level.
- The energy decreases at each subsequent trophic level is due to two reasons:
  - ✓ At each trophic, a part of the available energy is **lost in respiration** or used up in **metabolism**.
  - ✓ A part of the energy is **lost at each transformation**.

5.3.4. Limitations of Ecological Pyramids

- Ecological pyramids **do not consider the same species belonging to two or more trophic levels**.
- It assumes a simple food chain, something that seldom exists in nature; **it does not accommodate a food web**.
- Moreover, **saprophytes** (plant, fungus, or microorganism that lives on decaying matter) are **not given any place in ecological pyramids** even though they play a vital role in the ecosystem.

5.3.5. Biomagnification – Pollutants and Trophic Level

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- Pollutants move through the various trophic levels in an ecosystem.
- Non-degradable pollutants (**persistent pollutants**), which cannot be broken down by detrivores, not only **move through the various trophic levels** but also **remain in that tropic level for a very long duration**.
- **Chlorinated Hydrocarbons (Perfluoro Chlorides** – explained in the chapter on pollution) are the most damaging non-degradable pollutants that are long-lasting.

Movement of these pollutants involves two main processes:

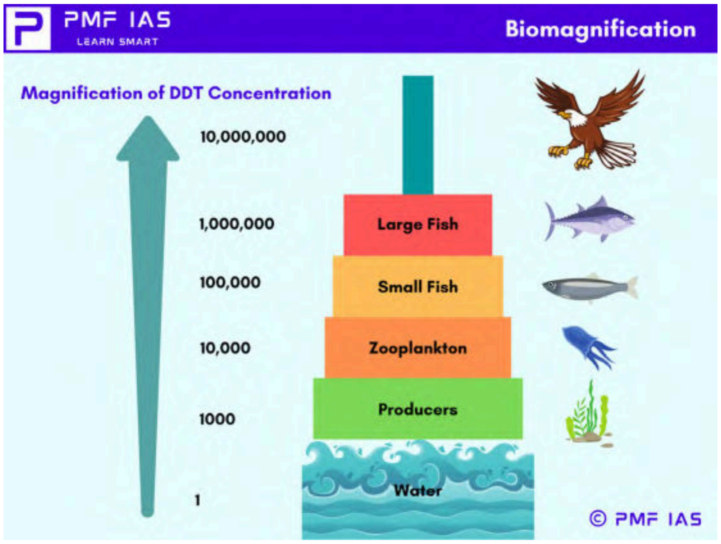
1) **Bioaccumulation**
2) **Biomagnification**

Bioaccumulation

- Bioaccumulation is the **gradual accumulation of pollutants, chemicals (chronic poisoning) or other substances in an organism**.
- Bioaccumulation occurs when the rate of loss of the substance from the body of the organism through **catabolism (breakdown of complex molecules in living organisms), or excretion** is lower than the rate of accumulation of the substance.
- As **persistent organic pollutants like DDT** are long-lasting, the **risk of bioaccumulation is high** even if the environmental levels of the pollutant are not high.

Biomagnification

- Biomagnification refers **to progressive bioaccumulation (increase in concentration) at each tropical level with the passage of time.**
- In order for biomagnification to occur, the pollutant must have:
  1. **a long biological half-life (long-lived),**
  2. **must not be soluble in water but must be soluble in fats. E.g., DDT.**
- If the pollutant is soluble in water, it will be **excreted** by the organism.
- Pollutants that dissolve in fats are retained for a long time.
- Hence it is traditional to measure the **amount of pollutants in fatty tissues** of organisms such as fish.
- **In mammals, milk produced by females is tested** for pollutants **since the milk has a lot of fat in**.



Biomagnification of DDT in an Aquatic Food Chain

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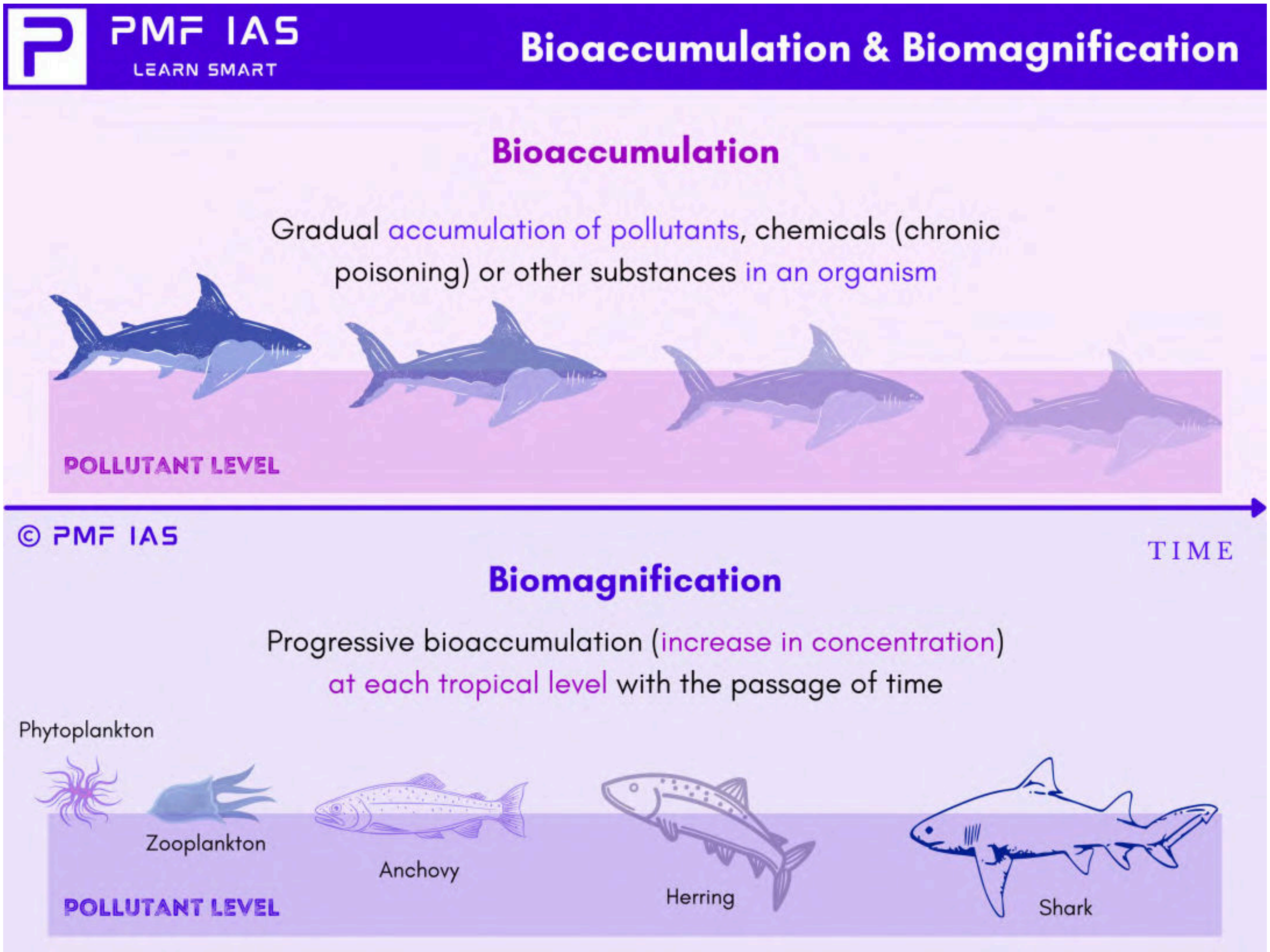

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6. Biogeo Chemical Cycling or Nutrient Cycling

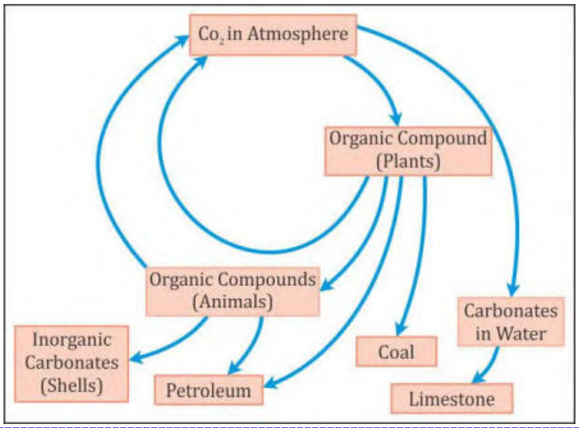
- **Energy flow** and **nutrient circulation** are the major functions of the ecosystem.
- Energy is lost as heat forever in terms of the usefulness of the system. On the other hand, nutrients of food matter never get used up. They can be **recycled** again and again indefinitely.
- Carbon, hydrogen, oxygen, nitrogen and phosphorus as elements and compounds make up 97% of the mass of our bodies and are more than 95% of the mass of all living organisms.
- In addition to these, about 15 to 25 other elements are needed in some form for the survival and good health of plants and animals.
- These elements or mineral nutrients are always in circulation, moving from non-living to living and then back to the non-living components of the ecosystem in a circular fashion.
- This circular fashion is known as **biogeochemical cycling** (bio for living; geo for atmosphere).
- Among the most important nutrient cycles are the **carbon nutrient cycle** and the **nitrogen nutrient cycle**.
- There are many other nutrient cycles that are important in ecology, including many trace mineral nutrient cycles.

6.1. Types of Nutrient Cycles

- Based on the replacement period, a nutrient cycle is referred to as the **Perfect or Imperfect cycle**.
- A perfect nutrient cycle is one in which **nutrients are replaced as fast as they are utilized**.
- **Most gaseous cycles** are generally considered **perfect cycles**.
- In contrast, **sedimentary cycles** are considered **relatively imperfect**, as **some nutrients are lost from the cycle and get locked into sediments,** and so become unavailable for immediate cycling.
- Based on the nature of the reservoir, a nutrient cycle is referred to as the **Gaseous or Sedimentary cycle**.
- **Gaseous Cycle:** the reservoir is the **atmosphere or the hydrosphere** — **water cycle, carbon cycle, nitrogen cycle, methane (compound) cycle**, etc. and
- **Sedimentary Cycle:** the **reservoir is the earth's crust** (soluble elements mostly found in earth's crust) — **phosphorous cycle, sulphur cycle, calcium cycle, magnesium cycle** etc.

6.2. Carbon Cycle (Gaseous Cycle)

- Carbon is a minor constituent of the atmosphere as compared to oxygen and nitrogen.
- However, without carbon dioxide, life could not exist because it is vital for the **production of carbohydrates through photosynthesis** by plants and **phytoplankton**.
- It is the element that anchors all organic substances from coal and oil to DNA (deoxyribonucleic acid: the compound that carries genetic information).



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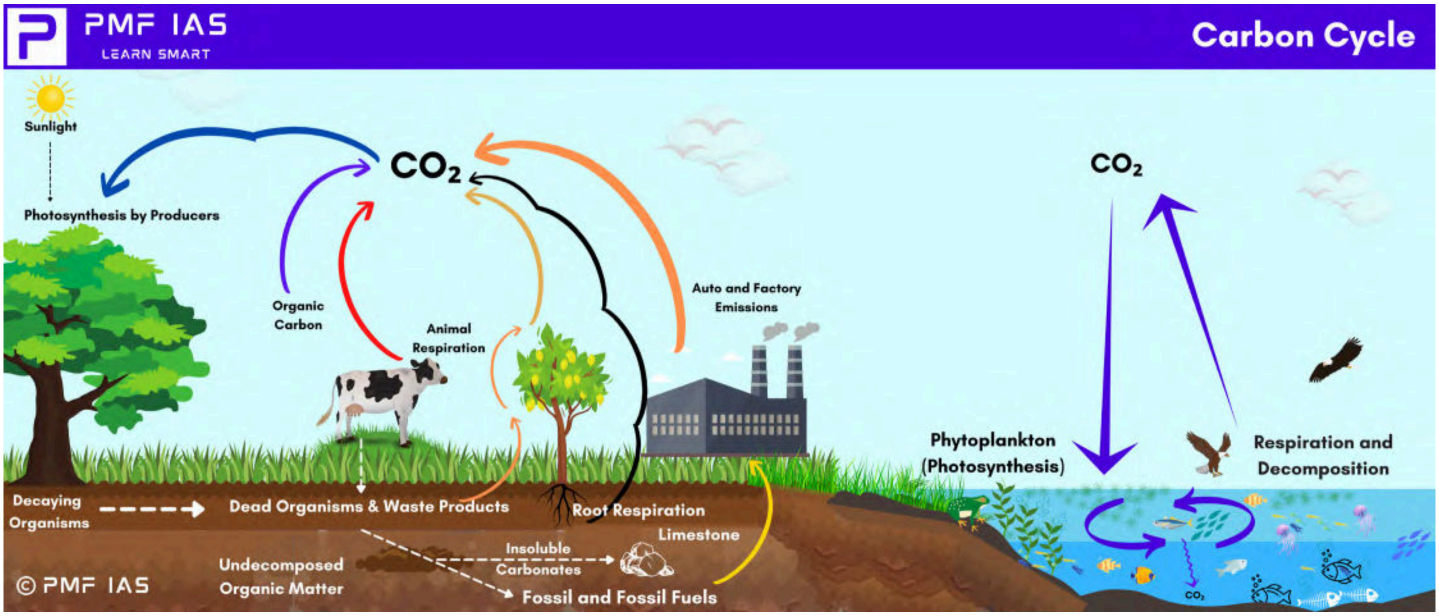
6.2.1. Steps in Carbon Cycle

- Carbon is present in the atmosphere, mainly in the form of carbon dioxide (CO_2).
- The carbon cycle involves a continuous exchange of carbon between the atmosphere and organisms.
- Carbon from the atmosphere moves to green plants and **phytoplankton** by the process of **photosynthesis** and then to animals.
- By the process of **respiration and decomposition of dead organic matter**, **it returns to the atmosphere**. It is usually a short-term cycle.
- **Decomposition of decaying organic matter** (carbohydrate, proteins and lipids, which are made up of **carbon, oxygen, hydrogen** and **nitrogen**) produces **nitrogen** and **carbon dioxide**.
- Some carbon also enters a long-term cycle. It accumulates as **un-decomposed organic matter in the peaty layers of marshy soil** or as **insoluble carbonates in bottom sediments of aquatic systems,** which take a long time to be released.
- In **deep oceans**, such carbon can remain buried for millions of years till geological movement may lift these rocks above sea level.
- These rocks may be exposed to erosion, releasing their **carbon dioxide, carbonates** and **bicarbonates** into streams and rivers.
- Fossil fuels such as coals, oil and natural gas are organic compounds that were buried before they could be decomposed and were subsequently transformed by time and geological processes into fossil fuels.
- When they are burned, the carbon stored in them is released back into the atmosphere as carbon dioxide.



Q. Consider the following:

1) Photosynthesis
2) Respiration
3) Decay of organic matter
4) Volcanic action

Which of the above add carbon dioxide to the carbon cycle on earth?

a) 1 and 4 only
b) 2 and 3 only
c) 2,3 and 4 only

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d) 1, 2, 3 and 4

Explanation:

- Photosynthesis takes out CO_2 from the carbon cycle. Rest all add CO_2.
- Decomposition of organic matter releases carbon dioxide, whereas undecomposed organic matter adds carbon to the soil in the form of insoluble carbonates and hence contributes to the carbon cycle.

Answer: c) 2,3 and 4 only

Q. Which one of the following is the process involved in photosynthesis?

a) Potential energy is released to form free energy
b) Free energy is converted into potential energy and stored
c) Food is oxidized to release carbon dioxide and water
d) Oxygen is taken, and carbon dioxide and water vapour are given out

Explanation:

- Potential energy is released to form free energy (false – sun's free energy is converted into potential energy in photosynthesis)
- Food is oxidized to release carbon dioxide and water (false – oxygen is released and not carbon dioxide)
- Oxygen is taken, and carbon dioxide and water vapour are given out (false – CO_2 is taken, and oxygen is given out)
- Sunlight (free energy) is converted into carbohydrates (potential energy) using water and carbon dioxide. Oxygen is released in the process.

Answer: b)

6.3. Nitrogen Cycle (Gaseous Cycle)

- Apart from **carbon, hydrogen and oxygen, nitrogen** is the most prevalent element in living organisms.
- Nitrogen is a constituent of **amino acids, proteins, hormones, chlorophylls** and many vitamins (explained in Biology NCERT).
- Plants compete with microbes for the limited nitrogen that is available in the soil. Thus, nitrogen is a **limiting nutrient** for both natural and agricultural ecosystems.
- Nitrogen exists as two nitrogen atoms (N_2) joined by a very strong **triple covalent bond ($N \equiv N$)**.
- In nature, **lightning** and **ultraviolet radiation** provide enough energy to convert nitrogen to **nitrogen oxides (NO, NO_2, N_2O)**.
- **Industrial combustions, forest fires, automobile exhausts and power-generating stations** are also sources of atmospheric **nitrogen oxides**.

6.3.1. Nitrogen Fixing – N_2 to NH_3

- There is an inexhaustible supply of nitrogen in the atmosphere, but the elemental form cannot be used directly by most living organisms.
- **Nitrogen needs to be 'fixed'**, that is, **converted to ammonia, nitrites or nitrates**, before it can be taken up by plants.

Nitrogen Cycle ➔ Nitrogen → Ammonia or Ammonium Ions → Nitrite/Nitrate → Nitrogen

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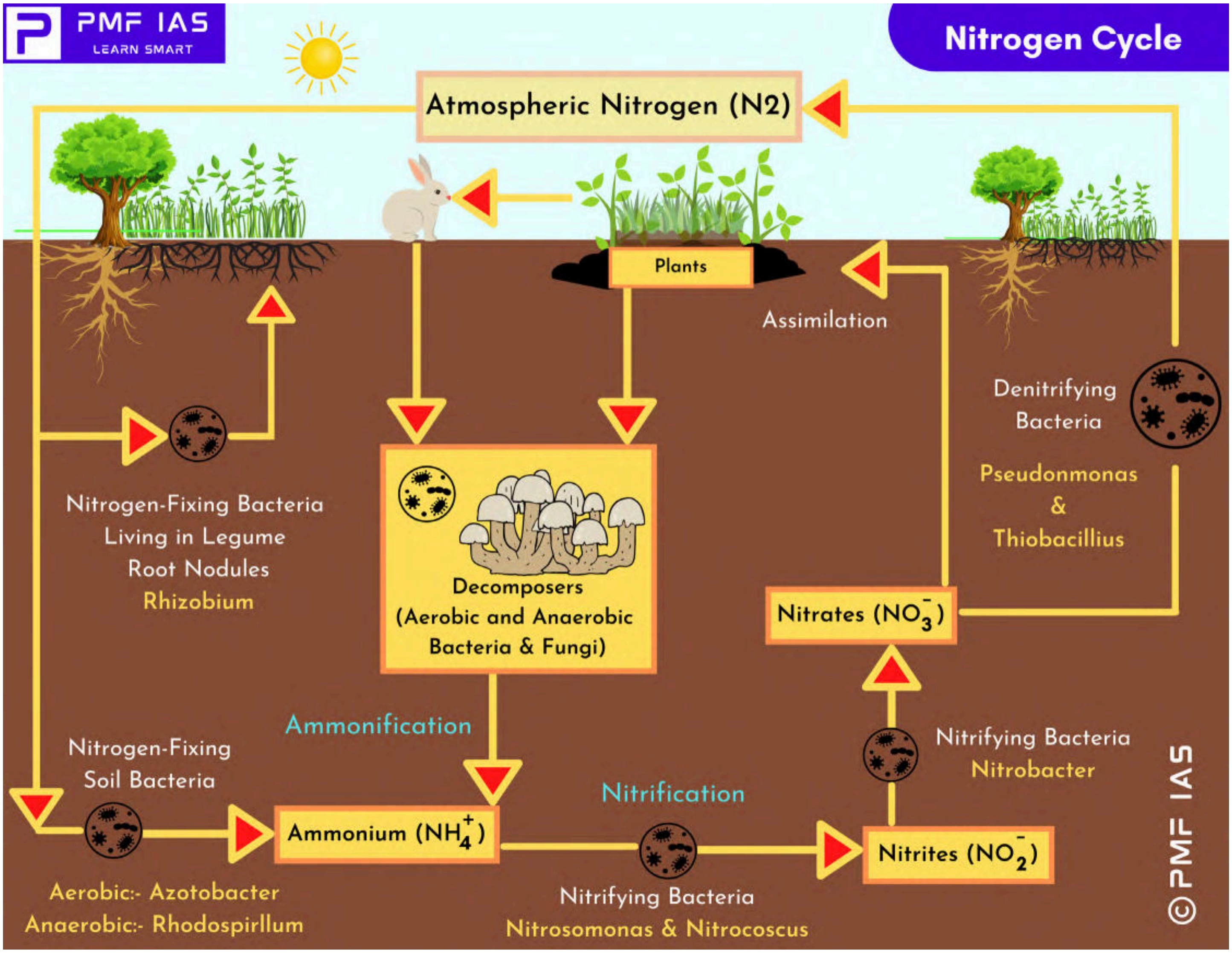

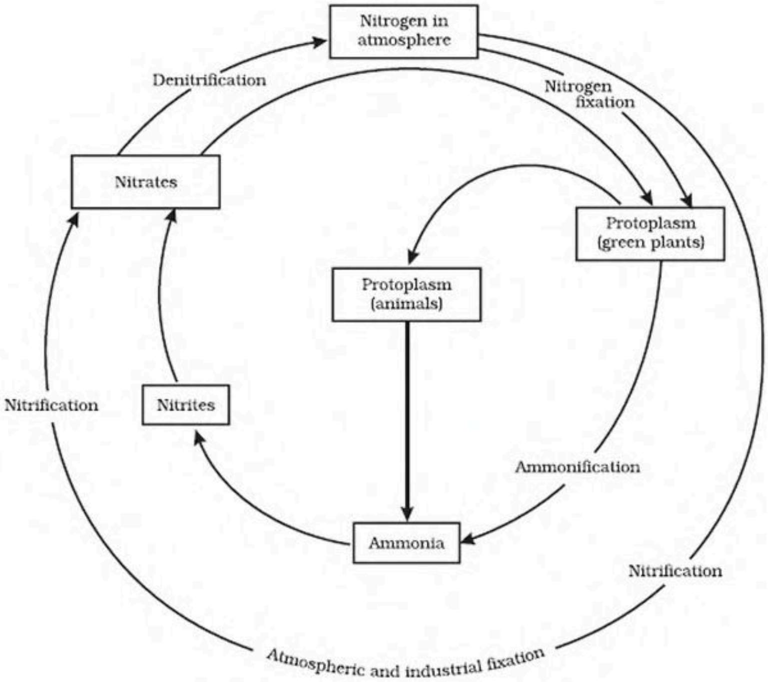

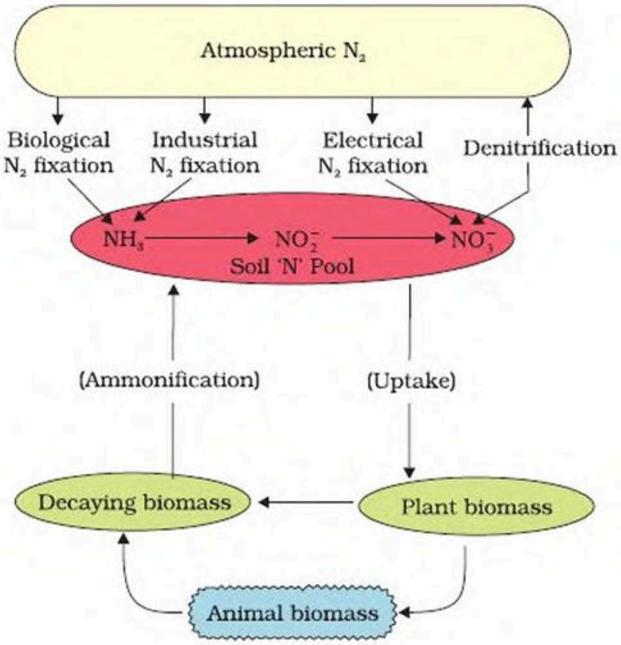

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- Nitrogen fixation on earth is accomplished in three different ways:
  a) **By microorganisms (bacteria and blue-green algae),**
  b) **By man using industrial processes (fertilizer factories) and**
  c) **To a limited extent by atmospheric phenomena such as thunder and lighting**.
- Certain microorganisms can fix **atmospheric nitrogen** into **ammonia (NH_3)** and **ammonium ions (NH_4+)**.
- **Ammonia (NH_3)** is a molecule consisting of nitrogen and hydrogen, **while ammonium (NH4+) is an ion of ammonia** that is formed by **accepting a hydrogen ion**.
- The enzyme, **nitrogenase** which is capable of **nitrogen reduction,** is present exclusively in **prokaryotes**.
- Such microbes are called N_2-fixers. These include:
  - ✓ **Free-living nitrogen-fixing bacteria** (non-symbiotic nitrogen-fixing bacteria or nitrogen-fixing soil bacteria)
    - ❖ E.g., **aerobic Azotobacter** and **Beijemickia**; **anaerobic Clostridium** and **Rhodospirillum**.
  - ✓ **Symbiotic nitrogen-fixing bacteria** living in association with **leguminous plants** and non-leguminous **root nodule plants**.
    - ❖ E.g., **Rhizobium**
  - ✓ **Some cyanobacteria** (**a major source of nitrogen fixation in oceans — blue-green algae**)
    - ❖ E.g., **Nostoc, Anabaena, Spirulina** etc.
- **Leguminous:** denoting plants of the pea family (Leguminosae), typically having seeds in pods, distinctive flowers, and root nodules containing nitrogen-fixing bacteria.

6.3.2. Nitrification – Ammonia to Nitrates

- Ammonium ions can be directly taken up as a source of nitrogen by some plants.
- Others absorb **nitrites or nitrates** , which are obtained by **oxidizing ammonia and ammonium ions** by two groups of specialized bacteria.
  1. Ammonium ions are first oxidized to **nitrite** by the bacteria **Nitrosomonas** and/or **Nitrococcus**.
  2. The nitrite is further oxidized to **nitrate** with the help of the bacterium **Nitrobacter**.
- These steps are called **nitrification**. These **nitrifying bacteria** are **chemoautotrophs** **(they use inorganic chemical energy sources to synthesize organic compounds from carbon dioxide)**.
- The nitrate thus formed is absorbed by plants and is transported to the leaves.
- **In leaves**, it is **reduced to form ammonia** that finally forms the amine group of **amino acids**, which are the building blocks of proteins. These then go through higher trophic levels of the ecosystem.
- **Nitrification is essential in agricultural systems**, where fertilizer is often applied as ammonia.
- Conversion of **this ammonia to nitrate increases nitrogen leaching** because **nitrate is more water-soluble than ammonia**.
- **Nitrification** also plays an essential role in the **removal of nitrogen from municipal wastewater**.
- The conventional removal is nitrification, followed by **denitrification**.

6.3.3. Ammonification – Urea, Uric Acid to Ammonia

- Living organisms produce nitrogenous waste products such as **urea and uric acid (organic nitrogen)**.
- These waste products, as well as dead remains of organisms, are converted back into **inorganic ammonia and ammonium ions** by the bacteria. This process is called **ammonification**.
- Some of this ammonia **volatilizes and re-enters the atmosphere**, but most of it is converted into **nitrate** by soil bacteria.

6.3.4. Denitrification – Nitrate to Nitrogen

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- Nitrate present in the soil is reduced to nitrogen by the process of **denitrification**.
- In the soil as well as oceans, there are special denitrifying bacteria (**pseudomonas** and **thiobacillus**), which convert the **nitrates/nitrites to elemental nitrogen**.
- This nitrogen escapes into the atmosphere, thus completing the cycle.

Step 1: N_2 Fixing ➔ Nitrogen → Ammonia or Ammonium Ions

Step 2: Nitrification ➔ Ammonia or Ammonium Ions → Nitrite → Nitrate

Step 3: Ammonification ➔ Dead Matter + Animal Waste (Urea, Uric Acid) → Ammonia or Ammonium Ions

- ✓ **Most of the ammonia escapes into the atmosphere**.
- ✓ **Rest is nitrified (Step 2) to nitrates**.
- ✓ **Some of the nitrates is available for plants. Rest is Denitrified (Step 4).**

Step 4: Denitrification ➔ Nitrate → Nitrogen

- The amount of **nitrogen fixed by humans through the industrial process has far exceeded the amount fixed by the Natural Cycle**.
- As a result, nitrogen fixed by humans has become a pollutant which can disrupt the balance of nitrogen.
- It may lead to **acid rain, eutrophication** & **harmful algal blooms** (explained in the subsequent chapters).

Q. Which of the following adds/add nitrogen to the soil?

1) Excretion of urea by animals
2) Burning of coal by man
3) Death of vegetation

Select the correct answer using the codes given below.

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- All the above three adds to the nitrogen cycle.
- Burning coal releases **CO, CO_2, sulphur dioxide** and **oxides of nitrogen** – air pollutants.
- **Oxides of nitrogen** fall on earth as **acid rain**.
- **Acidic rain** is a complex mixture of **nitrous, nitric, sulphurous, and sulfuric acids** which all combine to lower the pH.
- But, the question asks, “Which of the following adds/add nitrogen to the soil?”
- **Animal waste like urea, uric acid and the death of vegetation add nitrogen in the form of nitrates directly into the soil**.
- **Coal combustion adds nitrogen to the atmosphere,** and from there, **it falls back to earth in the form of acid rain, and acid rain adds nitrogen to the soil**.
- The release of **nitric oxides** into the air in large quantities causes **smog and acid rain**.
- The increase in **nitrogen and nitrous oxide** is caused by **automobiles, power plants** and a wide variety of **industries**.”
- **Nitrogen will only react with oxygen in the presence of high temperatures and pressures** found near **lightning bolts and in combustion reactions in power plants or internal combustion engines**.
- **Nitric oxide (NO), and nitrogen dioxide (NO_2)**, are formed under these conditions.

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- Eventually, **nitrogen dioxide may react with water** in the rain to form **nitric acid, HNO_3**.
- The nitrates thus formed may be utilized by plants as a nutrient (so, the soil gets nitrogen from acid rain)."
- From the above explanation, it is clear that the **burning of coal by man adds nitrogen to the soil, but indirectly through acid rain**.

Answer: Official UPSC Key says the answer is c) 1 and 3 only.

Q. Consider the following:

1) Carbon dioxide
2) Oxides of Nitrogen
3) Oxides of Sulphur

Which of the above is/are the emission/emissions from coal combustion at thermal power plants?

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- **Burning coal releases CO, CO_2, sulphur dioxide** and **oxides of nitrogen**.

Answer: d) 1, 2 and 3

Q. What can be the impact of excessive/inappropriate use of nitrogenous fertilizers in agriculture?

1) Proliferation of nitrogen-fixing microorganisms in soil can occur.
2) Increase in the acidity of soil can take place.
3) Leaching of nitrate to the groundwater can occur.

Select the correct answer using the code given below.

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

Explanation:

- **Nitrification** is **important in agricultural systems**, where fertilizer is often applied as **ammonia**.
- **Conversion of this ammonia to nitrate increases nitrogen leaching** because **nitrate is more water-soluble**.
- **Agricultural fertilization and the use of nitrogen-fixing plants** also **contribute to atmospheric NO_x** by promoting nitrogen fixation by microorganisms.
- **Excess NO_x leads to acid rain**. **Acid rain lowers the pH of the soil (increase in acidity of the soil)**
- The **legume-rhizobium symbiosis is a classic example of mutualism** — **rhizobia supply ammonia or amino acids to the plant and in return receive organic acids as a carbon and energy source**.
- So, **excessive/inappropriate use of nitrogenous fertilizers can make the plants independent of both symbiotic and free-living nitrogen fixers**. Fixers do not get food from the plants due to a broken relationship and other factors. So, their population decreases.

Answer: c) 2 and 3 only

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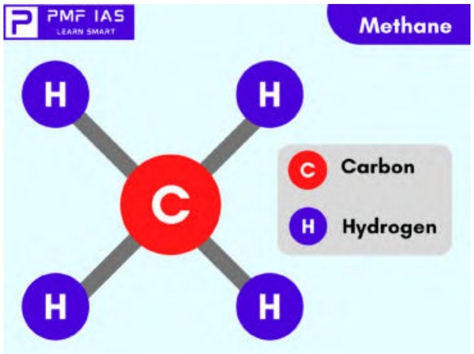
6.4. Methane (CH_4) Cycle (Compound Gaseous Cycle)

- The methane cycle is a **compound gaseous cycle**.
- Methane is the simplest hydrocarbon, consisting of **1 carbon atom & 4 hydrogen atoms**.



- Methane is the main constituent of **natural gas**.
- It is an **odourless, colourless, tasteless gas** that is **lighter than air**.
- When methane burns in the air it has a **blue flame (because of complete combustion)**.
- In the **presence of oxygen**, methane burns to give off **carbon dioxide (CO_2) & water (H_2O)**.
- Methane, in general, **is very stable**, but mixtures of methane and air, with the methane content between 5 and 14 per cent by volume, are explosive.
- Methane is the most important **greenhouse gas** after **carbon dioxide**.
- The **20-year global warming potential** of methane is **84,** i.e., over a 20-year period, **it traps 84 times more heat per mass unit than carbon dioxide (CO_2) — it is a more potent GHG than CO_2**.
- However, **its lifetime** in the atmosphere is **much shorter** than **carbon dioxide (i.e., it is short-lived)**.
- It contributes to the formation of **ground-level ozone**, a dangerous air pollutant.

6.4.1. Natural Sources of Methane Emissions

- Methane is naturally produced from the **decomposition of animal wastes and biological matter**.
- Major natural sources include **wetlands & oceans** & from the **digestive processes** of termites.

Wetlands

- **Methanogens** are **microorganisms** that produce methane as a **metabolic by-product** during the **decomposition** of organic matter in **hypoxic (low oxygen)** conditions.
- They are **prokaryotic** and belong to the domain of **archaea** (**archaebacteria** — microorganisms that are more primitive, ancient, and less developed than bacteria).
- Wetlands provide a habitat favourable to **methanogens** and contribute to about **80% of the global methane emissions from natural sources**.

Termites

- Microbes in the **guts of termites** produce methane through **anaerobic fermentation** as part of their **normal digestive process.**

Oceans

- The source of methane from oceans is not entirely clear.
- But two identified sources include the **anaerobic (oxygen-free) digestion** in marine **zooplankton**, fish & also from methane produced in **sediments & drainage** areas along coastal regions.

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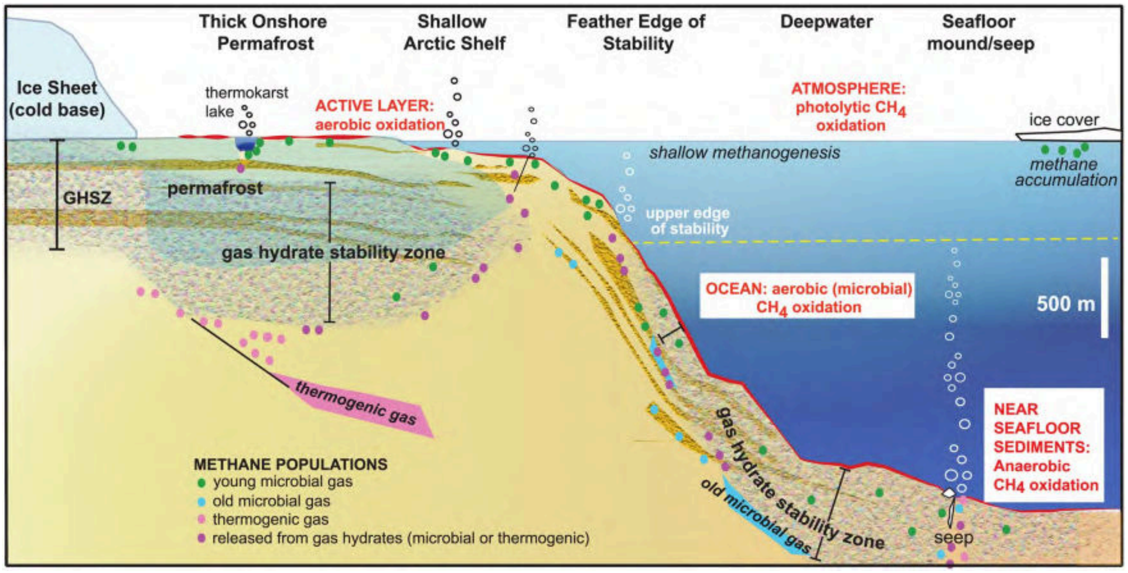
Methane Hydrates

- **Methane hydrates** or **clathrates** are formed when **hydrogen-bonded water & methane gas** come into contact at **high pressures** & **low temperatures** in oceans.
- Methane hydrates are in the form of **crystalline ice** (because of **high pressures & low temperatures** in oceans) that consists of a **methane molecule** surrounded by a **cage of interlocking water molecules**.
- They cannot be brought to the surface as the reduced pressure and increase in temperature will cause the ice to melt and the **methane to escape**.
- **Ocean acidification, climate change**, or any other **anthropogenic disturbance** can destabilize the clathrates and lead to the release of an **immense amount of methane (it will lead to mass extinction)**.
- **Methane hydrates** are also **trapped in permafrost (the permanently frozen soil in the polar latitudes)**.
- Overall, the amount of methane stored in these hydrates globally is estimated to be **very large**, making the **potential for the release of large quantities of methane** a real possibility due to **climate change**.



Permian–Triassic extinction event (Third Mass Extinction)

- The Permian–Triassic (P-T) extinction event is also known as the **Great Dying**.
- It occurred about 252 Ma (million years) ago.
- It is the earth's **most severe** known extinction event, with up to **96% of all marine species** and **70% of terrestrial vertebrate species becoming extinct**.
- It is the only known mass extinction of insects.
- Suggested causes include **large meteor impact events**, **massive volcanism** such as that of the **Siberian Traps**, **run-away greenhouse effect triggered by the sudden release of methane from the sea floor** due to methane-producing microbes known as **methanogens**.

6.4.2. Human Sources of Methane Emissions

- Globally, **50 – 65% of total CH_4 emissions come from human activities**.
- **More than 50%** of the **global methane emissions** stem from human activities in 3 sectors:
  1. **Agriculture (40%)**
  2. **Fossil Fuels (35%)**
  3. **Waste (20%)**
- According to UNEP, **human-caused methane** emissions have to be reduced **by 45% by 2030**.

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- It has recommended different targets & areas for different countries.
- **For India,** it has **recommended** emission reduction in the **waste sector (by improving sewage disposal)**.

Landfills

- Methane is generated in landfills as waste decomposes **under anaerobic (oxygen-free) conditions**.
- The amount of methane created depends on the quantity & moisture content of the waste.

Wastewater Treatment

- Wastewater from sewage is treated to remove soluble organic matter, pathogenic organisms, etc.
- These treatment processes can produce methane emissions if organic ingredients are **treated without oxygen (anaerobic conditions)**.

Fossil Fuels

- Fossil fuels are formed by natural processes such as the **anaerobic decomposition** of buried dead organisms.
- Methane is the primary component of **natural gas**. It is released during the production, processing, storage, transmission, & distribution of natural gas.
- In addition, **methane trapped in coal deposits (Coalbed Methane)** is released during normal mining operations in both underground & surface mines.

Livestock

- Domesticated livestock such as cattle, buffalo etc., produce large amounts of methane as part of their **normal digestive processes**.
- In the stomach, **microbial fermentation** converts feed into products that can be digested.
- This process produces **methane as a by-product**, which is **exhaled** by the animal (cow breath).

Rice Cultivation

- Methane is produced **during flooded rice cultivation** by the decomposition of organic matter in the soil.
- Flooded soils are ideal environments for methane production because of their high levels of organic substrates, **oxygen-poor conditions**, & moisture.

Biomass Burning

- **Incomplete burning** of both living & dead organic matter results in the emission of methane.

⇨ **Human source> Natural Source**
⇨ **In Natural Source ➔ Wetlands > Termites > Oceans > Methane Hydrates**
⇨ **In Human Source ➔ Agriculture > Fossil Fuels > Waste**

6.4.3. Methane Sink

- Any process that **consumes methane from the atmosphere** can be considered a **"sink"** of methane.
- **Soils act as a major sink** for atmospheric methane through the **methanotrophic bacteria** that reside within them.
- These bacteria use **methane as a source of energy** in a process called **Methane Oxidation**.

Reaction with the hydroxyl radical

- The main mechanism for the removal of methane from the earth's atmosphere is **oxidation within the troposphere** by the **hydroxyl radical (OH)** — a neutral form of the hydroxide ion (OH−).
- A hydroxyl radical **(OH)** is a **negatively charged oxygen** atom bonded with the **hydrogen atom.**

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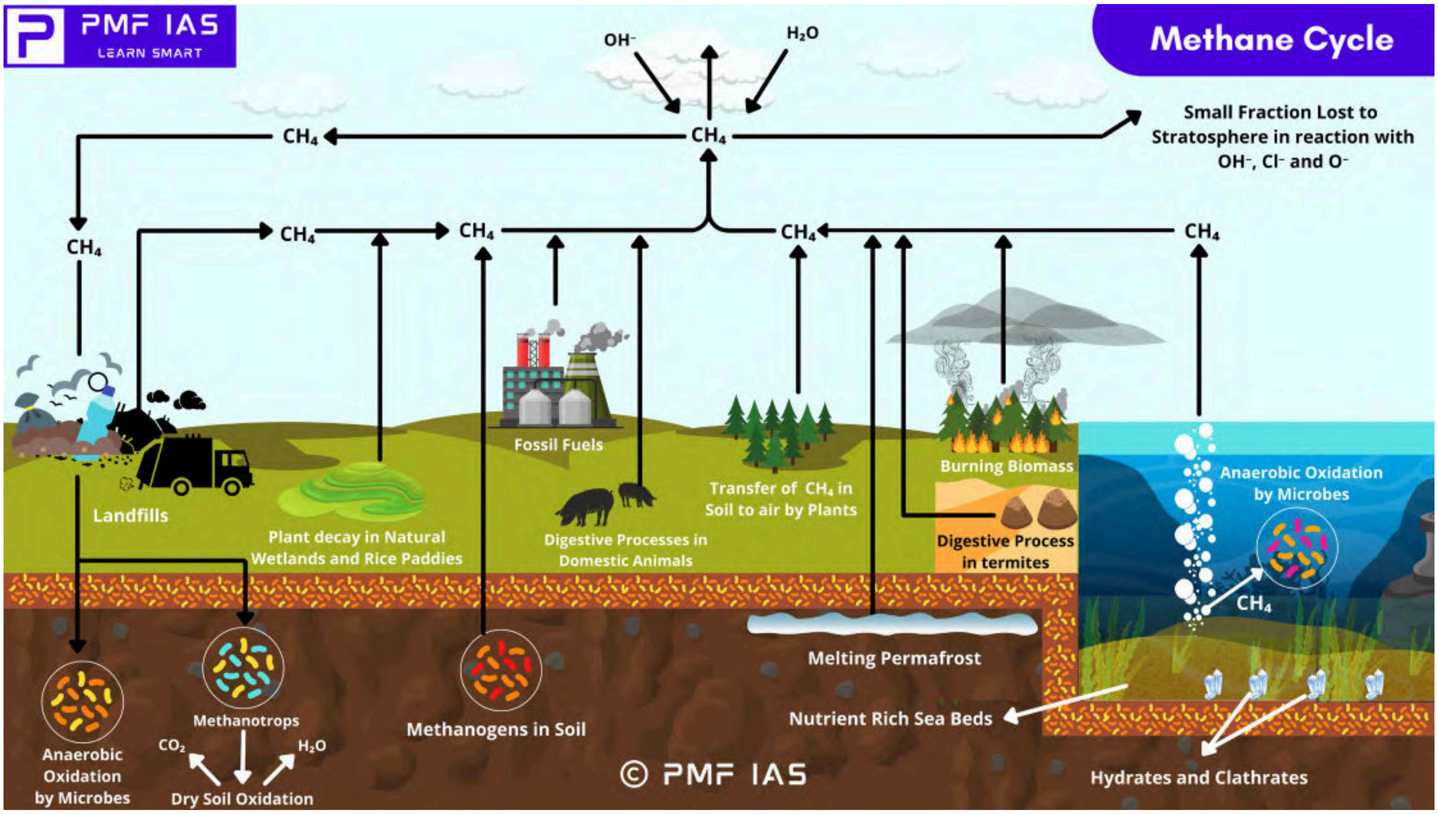
- **Hydroxyl radicals are a form of "sink"** because **they "scrub" the atmosphere clean of pollutant molecules** & break them down (For this reason, **OH is known as the 'cleanser of the atmosphere'**).
- After **reacting with OH,** atmospheric **methane is converted** to **CO_2 & water vapour** by a long series of chemical reactions.
- Some of the methane present in the troposphere passes into the **stratosphere,** where the same process scrubs the atmosphere clean of methane there.

Methane Hydrates

- **Clathrate deposits** were **once sinks** where methane was isolated.
- However, **as the planet warms**, some of these deep, **cold sediments are melting**, sending methane bubbling to the surface — **one of the great risks to lifeforms on earth**.



Q. Which of the following statements are correct about the deposits of methane hydrate? (2019)

1. Global warming might trigger the release of methane gas from these deposits
2. Large deposits of 'methane hydrate' are found in Arctic Tundra and under the seafloor.
3. Methane in the atmosphere oxidizes to carbon dioxide after a decade or two.

Select the correct answer using the code given below:

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: d) all

6.5. Phosphorus Cycle (Sedimentary cycle)

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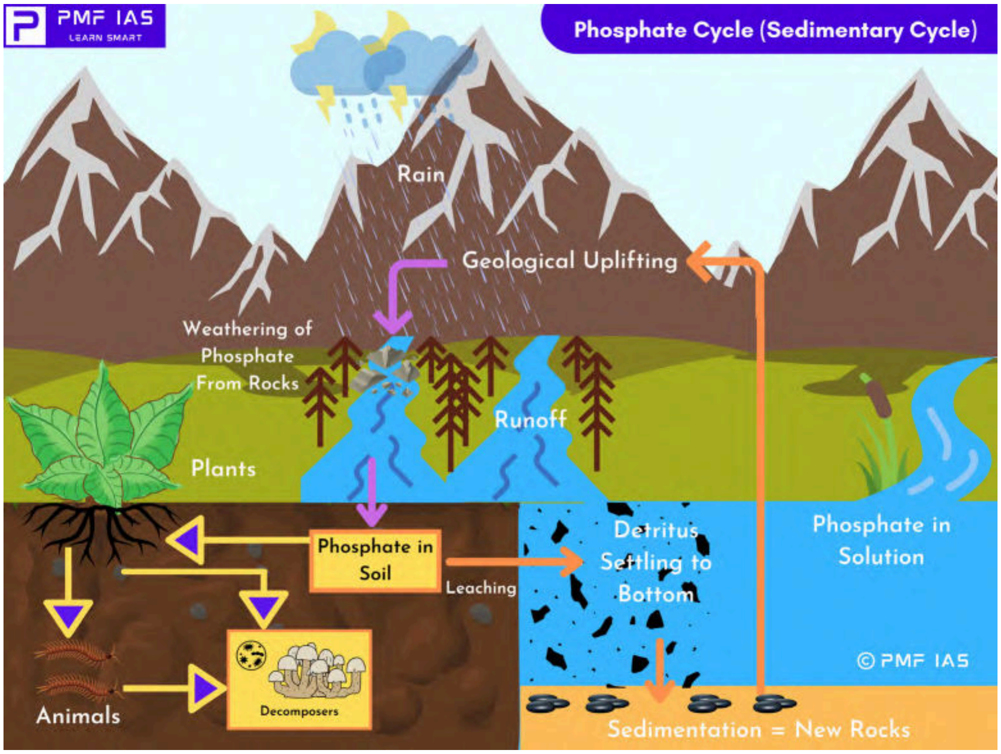
- Phosphorus plays a central role in **aquatic ecosystems** and water quality.
- Unlike carbon and nitrogen, which come primarily from the atmosphere, phosphorus occurs in large amounts as a **mineral in phosphate rocks** and enters the cycle from **erosion and mining activities**.
- This is the nutrient considered to be the **main cause of excessive growth of rooted and free-floating microscopic plants (phytoplankton) in lakes (which leads to eutrophication)**.



- The main storage for phosphorus is in the **earth's crust**.
- On land, phosphorus is usually found in the form of **phosphates**.
- By the process of weathering and erosion, phosphates enter rivers, streams and finally oceans.
- In the ocean, phosphorus accumulates on continental shelves in the form of **insoluble deposits**.
- After millions of years, the crustal plates rise from the seafloor and expose the phosphates on land.
- After more time, weathering will release them from rock, and the cycle's geochemical phase begins again.

6.6. Sulphur Cycle (Sedimentary cycle)

- The sulphur reservoir is in the **soil and sediments** where it is locked in organic (**coal, oil, peat**) and inorganic deposits (**pyrite rock, sulphur rock**) in the form of **sulphates sulphides,** and **organic sulphur**.
- It is released by weathering of rocks, erosional runoff and decomposition of organic matter and is carried to terrestrial and aquatic ecosystems in the salt solution.

6.6.1. Steps in Sulphur Cycle

- The sulphur cycle is **mostly sedimentary** except for two of its compounds, **hydrogen sulphide (H_2S)** and **sulphur dioxide (SO_2)**, which add a gaseous component.
- Sulphur enters the atmosphere from several sources like **volcanic eruptions, combustion of fossil fuels (coal, diesel etc.), from the surface of the ocean (Dimethyl Sulfide (DMS))** and **gases released by decomposition**.
- Atmospheric **hydrogen sulphide** also gets oxidized into **sulphur dioxide**.
- Atmospheric **sulphur dioxide** is carried back to the earth after being dissolved in rainwater as weak **sulphuric acid (acid rain)**.

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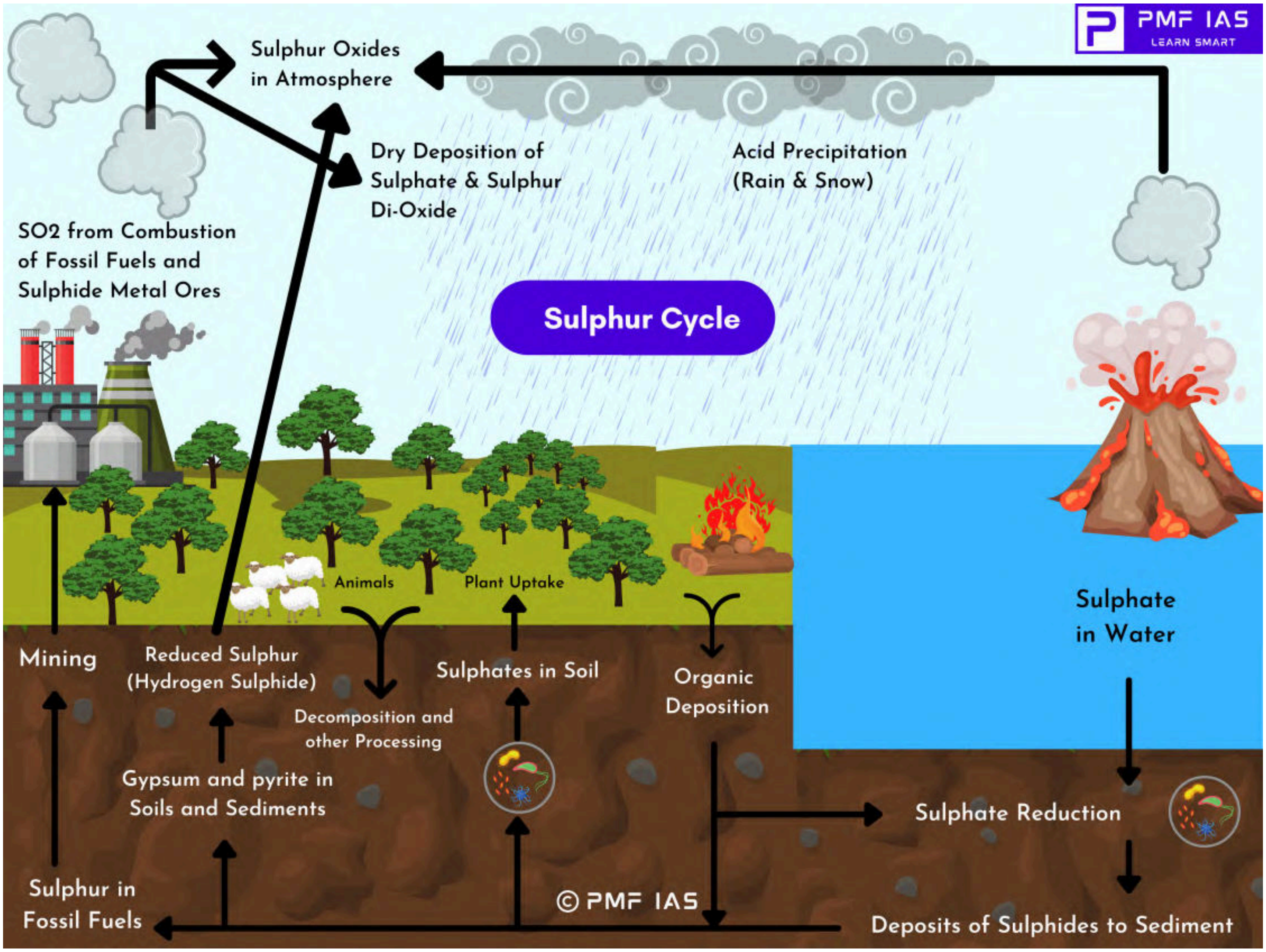
- Whatever the source, sulphur in the form of **sulphates** is taken up by plants and incorporated through a series of metabolic processes into **sulphur bearing amino acid** , which is incorporated in the proteins of autotroph tissues.
- It then passes through the **grazing food chain**.
- Sulphur bound in a living organism is carried back to the soil, to the bottom of ponds and lakes and seas **through excretion and decomposition of dead organic material**.



Q. With reference to agricultural soils, consider the following statements:

1) A high content of organic matter in soil drastically reduces its water holding capacity.
2) Soil does not play any role in the Sulphur cycle.
3) Irrigation over a period of time can contribute to the salinization of some agricultural lands.

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

- A high content of organic matter (humus) in soil increases its water holding capacity.

Explanation:

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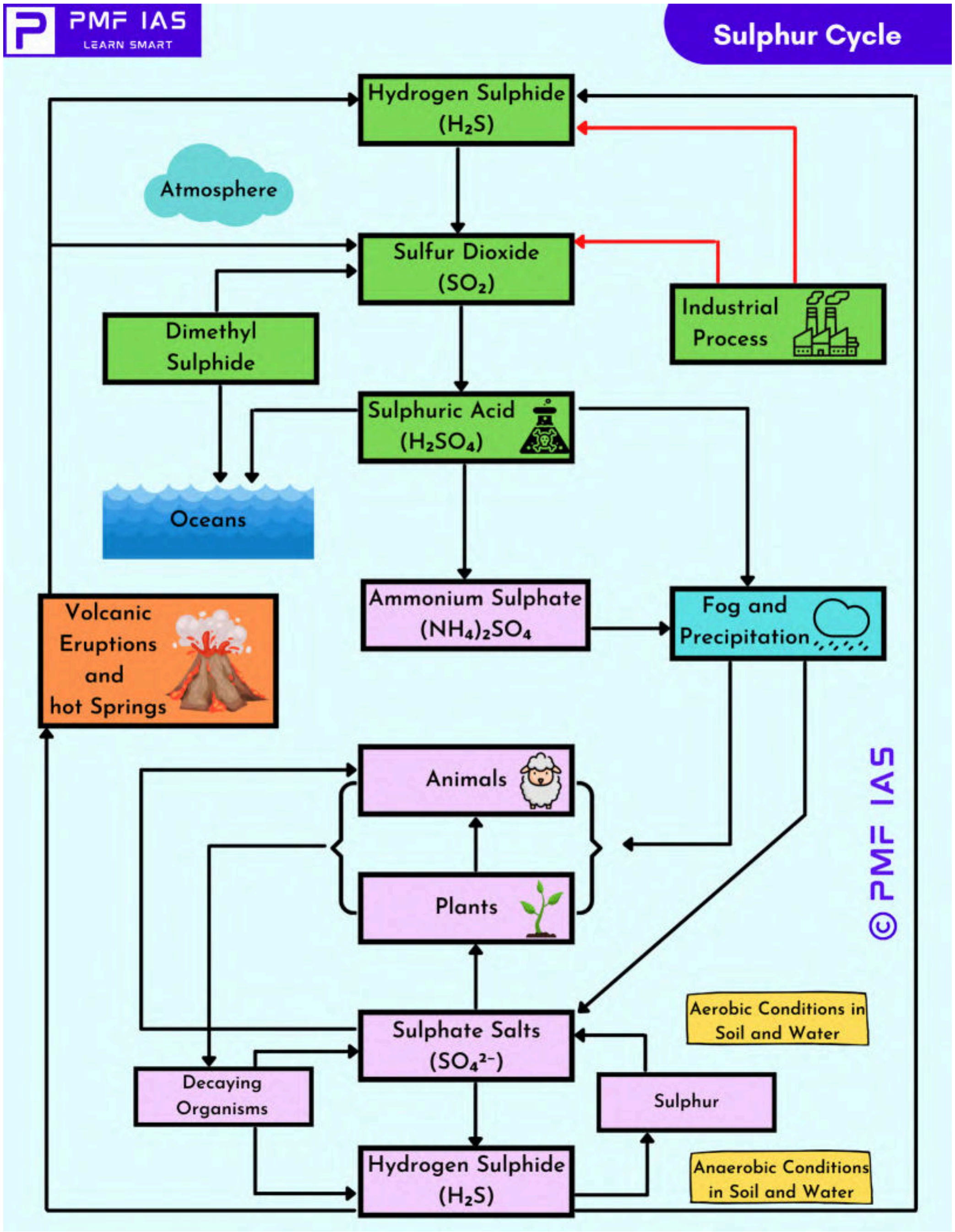
- Organic matter or humus enhances the water holding capacity of soil.
- In canal irrigated areas, the **groundwater level rises** and saline & alkaline efflorescences consisting of salts of sodium, calcium & magnesium appear on the surface as a layer of white salt through **capillary action**.
- Vast tracts of canal irrigated areas in Uttar Pradesh. Punjab and Haryana; arid regions of Rajasthan, semi-arid areas of Maharashtra, Gujarat, Andhra Pradesh, Telangana and Karnataka etc. are facing this problem.

Answer: b) 3 only



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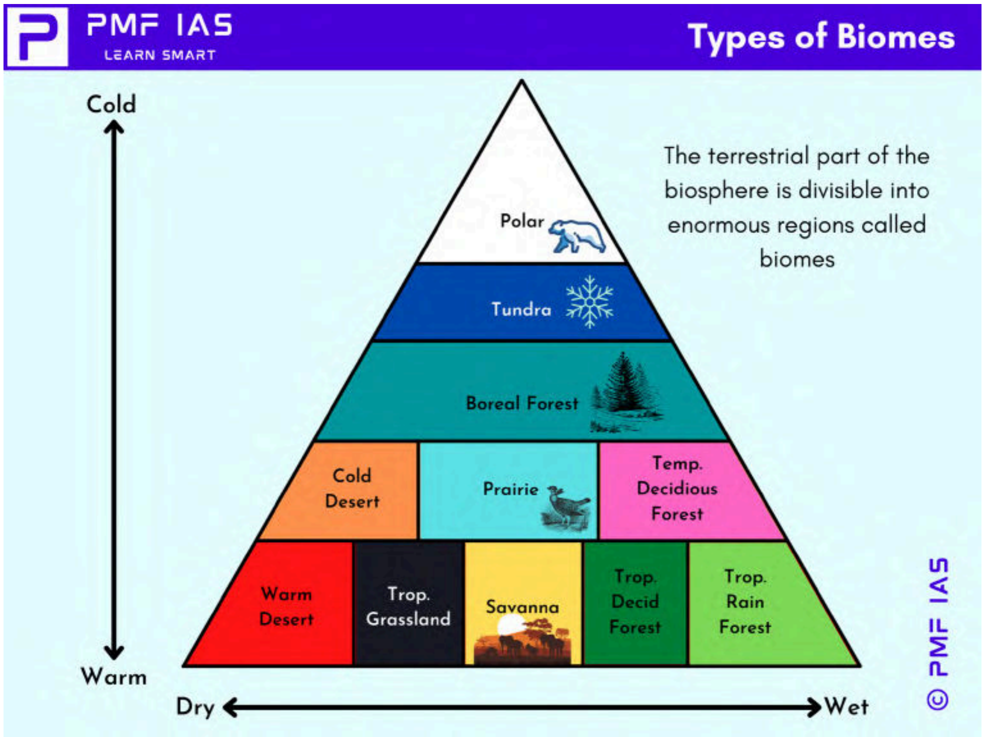
7. Natural Ecosystems

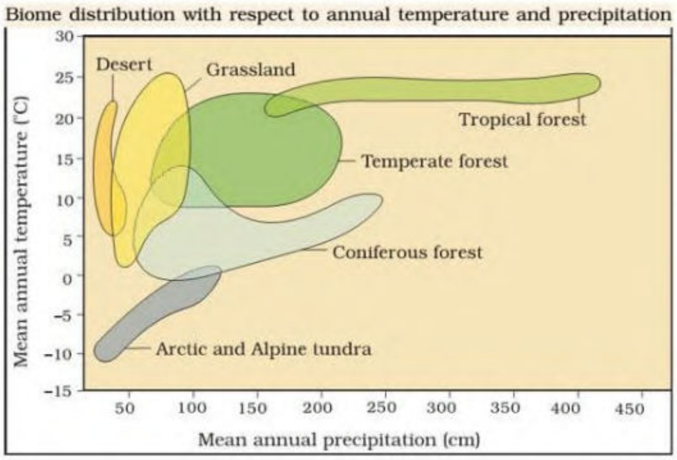
- A natural ecosystem is an assemblage of plants and animals which functions as a unit and is capable of maintaining its identity.
- There are two main categories of ecosystems: 1) Terrestrial ecosystem and 2) Aquatic ecosystem.

7.1. Terrestrial Ecosystems or Biomes

- The terrestrial part of the biosphere is divisible into enormous regions called **biomes**.
- **No two biomes are alike**. They are characterized by a distinct climate (precipitation and temperature mainly), vegetation, animal life and general soil type.
- The climate determines the boundaries of a biome and the abundance of plants and animals found in each one of them.

Major Biomes





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Tundra

- Arctic and Alpine Tundra Biome

Forest

- Taiga or Boreal Biome (Evergreen Coniferous forests)
- Temperate Deciduous Biome (North-Western Europe – British Type Climate)
- Temperate Rainforest Biome
- Sub-Tropical Deciduous Biome in Eastern China, South Eastern USA
- Temperate Deciduous Biome (Mediterranean Climate)
- Tropical Deciduous Biome (Monsoon Climate)
- Savanna or Tropical Wet and Dry Biome
- Tropical Rain Forest Biome

Grassland

- Steppe or Temperate Grassland Biome
- Savanna or Tropical Wet and Dry Biome (Tropical Shrublands and Grasslands)

Desert

- Tropical and Mid Latitude Desert Biome

For the detailed explanation and maps of biomes, you must go through ***PMF IAS Geography > Climatology > Climatic Regions****. Here we have discussed the content only from the environment and ecology perspective.*

7.1.2. Tundra Biome

- There are two types of tundra – arctic and alpine.
- Alpine tundra occurs at high mountains above the tree line. E.g., High ranges of the Himalayas, Andes, Alps etc.
- There are **no trees** in the tundra (due to **permafrost** — **ground remains completely frozen — (0°C) or colder — for at least two years straight**).

- The lowest form of vegetation, like **mosses, lichens** are sparsely found on bare rocks.
- Coastal lowlands have **reindeer moss** which provides the only pasturage for reindeer.
- In the summer, birds migrate north to prey on the numerous insects which emerge when the snow thaws.
- Insects have short life cycles which are completed during the favourable period of the year.
- Animals like the reindeer, arctic fox, wolves, muskox, polar bear, lemming, arctic hare, arctic willow live in the tundra region.
- **Reptiles and amphibians are almost absent**.
- Most of the animals have a **long life**, e.g. arctic willow has a life span of 150 to 300 years.
- They are protected from chillness by the presence of **thick cuticle and epidermal hair or fur**.

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- Mammals **have a large body size and small tail and ears to avoid the loss of heat from the surface**.

7.1.3. Taiga or Boreal Biome

- Boreal forest soils are characterized by thin **podzols** and are rather poor. This is because:
  - ✓ **The weathering of rocks proceeds slowly** in cold environments.
  - ✓ **The litter derived from conifer needle (leaf) is decomposed very slowly** and is not rich in nutrients (humus content is low).
  - ✓ **Conifers do not shed their leaves frequently**.
- The predominant vegetation is an **evergreen coniferous forest** with species such as **spruce, fir** and **pine**.
- The conifers require little moisture are best suited to this type of sub-Arctic climate.
- **The productivity of boreal forests is lower than those of any other forest ecosystem**.
- Animals found in this region include Siberian tiger, wolverine, lynx, wolf, bear, red fox, squirrel, and amphibians like Hyla, Rana, etc.

Podzols

- Podzols are the typical soils of a **coniferous or boreal biome**.
- The top layer of the soil is **very thin** and is overlain over sandy or loamy subsurface, which has **no organic matter** (**lost due to leaching of nutrients** to the bottom layers).
- The soils are characterized by **low levels of moisture** (excessively drained) and **nutrients** and are loamy or sandy. Others have shallow rooting zones and poor drainage due to subsoil cementation.
- A low pH further compounds issue. The **low pH (acidic)** is due to **excessive leaching of alkaline** matter, which, if present, would neutralize the organic acids of the accumulating litter.
- Hence, most Podzols are **poor soils for agriculture**. They are primarily used for grazing.

7.1.4. Temperate Deciduous Biome (North-Western Europe – British Type Climate)

- Soils of temperate forests are **podzolic** and fairly deep.
- The natural vegetation of this climatic type is **deciduous**.
- The **trees shed their leaves in the cold season**.
- This is an **adaptation for protecting themselves against the winter snow and frost**.
- Shedding begins in autumn, the 'fall' season. Growth begins in spring.
- Some of the common species include **oak, elm, ash, birch, beech**, and **poplar**.

7.1.5. Temperate Rainforest Biome

- This is a small biome in terms of the area covered. The main stretch of this habitat is along **the north-western coast of North America from northern California through southern Alaska**.
- There are also **small areas in southern Chile, New Zealand, Australia** and a few other places around the world.
- **Big coniferous trees** dominate this habitat, including **Douglas fir, Western red cedar, Mountain hemlock, Western hemlock**, Sitka spruce and Lodgepole pine.

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- In addition to the trees, **mosses and lichens** are very common, often growing as **epiphytes** (a plant that grows **harmlessly (commensalism)** upon another plant).
- Grizzly bears are the common mammals found in Alaska.

7.1.6. Sub-Tropical Deciduous Biome in Eastern China, South-eastern USA

- It strangely supports luxuriant vegetation.
- The lowlands carry both evergreen broad-leaved forests and deciduous trees (hardwood).
- On the highlands, various species of conifers such as pines and cypresses are important.
- **Perennial plant growth is not checked by either a dry season or a cold season**.

7.1.7. Steppe or Temperate Grassland Biome

- They are practically **treeless**, and the **grasses are much shorter**.
- Grasses are **fresh and nutritious**. Poleward, an increase in precipitation gives rise to a transitional zone of wooded steppes where some conifers gradually appear.
- The steppes **do not have much animal diversity**.

7.1.8. Temperate Deciduous Biome (Mediterranean Climate)

- Trees with small broad leaves are widely spaced and **never very tall**.
- Regions with adequate rainfall are inhabited by low, broad-leafed evergreen trees (mostly **evergreen oaks**).
- **Fire is an important hazardous factor in this ecosystem**, and the adaptation of the plants enables them to regenerate quickly after being burnt.
- Plants are in a continuous struggle against heat, dry air, excessive evaporation and prolonged droughts.
- They are, in short **xerophytic (drought tolerant)**.

7.1.9. Tropical Deciduous Biome (Monsoon Climate)

- Tropical Monsoon Forests are also known as drought-deciduous forest, dry forest, dry deciduous forest, tropical deciduous forest.
- **Teak, neem, bamboos, sal, shisham, sandalwood, khair, mulberry** are some of the important species.

7.1.10. Savanna or Tropical Wet and Dry Biome

- The savanna landscape is typified by **tall grass and short trees**.
- The trees are deciduous, **shedding their leaves in the cool, dry season** to prevent excessive loss of water through transpiration, e.g., **acacias**.
- Trees usually have **broad trunks** with water-storing devices to survive through the prolonged drought.
- Many trees are umbrella-shaped, exposing only a narrow edge to the strong winds.
- The Savanna biome is **rich in mammal, bird, and reptile diversity**.

Savannas are Meant to Burn

- The fires are usually lit by cattle farmers as part of their traditional management of the savanna grasslands.
- Some fires are started to **stimulate new growth of nutritious grass** for their animals.
- Others are used **to control the numbers of parasitic ticks** or **manage the growth of thorny scrub**.
- Without fires, many savannahs (and the animals they support) would not exist and lighting them is a key management activity in many of the iconic protected areas of Africa.

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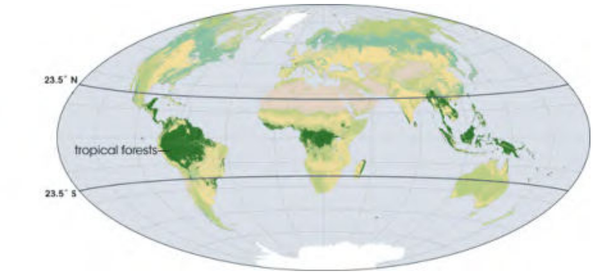
- Fires in savannahs are **carbon-neutral**: Fires in the savannah burn mainly dry grasses that regrow each year: the CO_2 released by fires is reabsorbed by the growth of new grass the next year.

7.1.11. Tropical Rainforest Biome

- High temperature and abundant rainfall support a luxuriant tropical rain forest.
- The equatorial vegetation comprises a multitude of evergreen trees, e.g. **mahogany, ebony**, dyewoods etc.
- In the coastal areas and brackish swamps, mangrove forests thrive.
- All plants struggle upwards (most epiphytes) for sunlight resulting in a peculiar layer arrangement (canopy).



⇨ **Epiphyte (commensalism – epiphyte benefits without troubling the host)**: An epiphyte is a plant that grows harmlessly upon another plant (such as a tree) and derives its moisture and nutrients from the air, rain, and sometimes from debris accumulating around it.

- In the recent few years, the rainforest has been under threat from deforestation and burning.
- **17 per cent of the entire rainforest** and about **20 per cent of the Brazilian rainforest** has been deforested.

Importance of Rainforests

Major oxygen producers

- Rainforests produce about **20 per cent of the earth's oxygen**.

Carbon sink

- Rainforests are our best defence against climate change as they can sequester a lot of carbon released by human activities.

Precipitation

- Through evapotranspiration, the rainforests are responsible for creating 50-75 per cent of their own precipitation.

Source to many rivers

- They are the source of many of the world's largest rivers.
- **Amazon, Mekong**, and **Congo (Zaire)** are some of the important rivers fed by the rainforests.

Climate

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- Tropical forests exchange vast amounts of water and energy with the atmosphere and are thought to be important in controlling local and regional climates.
- Water released into oceans by the rainforest rivers **influences the circulation of ocean currents**.
- This works as a **feedback mechanism**, as the process also sustains the regional climate on which it depends.

Biodiversity

- Tropical rainforests contain over **30 million species of plants and animals**. That's half of the earth's wildlife and at least two-thirds of its plant species!

Commercial Agriculture

- Rainforests offer a conducive climate for the cultivation of commercial crops such as **coffee, cocoa (chocolate), palm, rubber**, etc. (they require 100-200 cm of rainfall).

Indigenous communities

- Many indigenous people have been living in harmony with the rainforest for thousands of years, depending on it for their food, shelter, medicines and subsistence agriculture (slash and burn agriculture).

Importance of the Amazon Rainforest

- The Amazon basin produces about 20 per cent of the world's flow of fresh water into the oceans.
- It returns at least 75 per cent of the moisture to the westward-moving air mass.
- In fact, every country in South America other than **Chile (blocked from this moisture by the Andes)** benefits from Amazon moisture.

Threats: Frequent Fires in the Amazon Rainforest

Prolonged droughts due to climate change

- Amazonian forests and other tropical rainforest regions are **usually immune to fires** due to the high moisture content of the undergrowth beneath the protection of the canopy tree cover.
- But the severe droughts of 1997-98, 2005, 2010, and 2019 have forever changed this perception.
- These severe **mega-droughts** in the Amazon were most likely driven by large-scale climatic events, with the **warming of the Atlantic** and the **drying effects** of **El Niño Southern Oscillation (ENSO) events**.
- These droughts are clearly becoming far more frequent and more severe and are generating the conditions conducive for either human-made or natural wildfires.

Slash and burn agricultural practice

- People clear the land by cutting down the vegetation during the rainy season, letting the trees dry out and burning them during the dry season.
- Fully clearing the dense forest for agricultural use can take several years of slashing and burning.

Intentional fires caused by land grabbers

- They are manmade and are mostly set illegally by landgrabbers who are clearing the forest for **cattle ranching** and **soybean cultivation**.

Political discourse

- President Jair Bolsonaro has decreased the power and autonomy of forest protection agencies.
- Forest clearing has been encouraged by agricultural subsidies, timber concessions, etc.

How do the fires in Amazon affect the world?

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Carbon sink to carbon source and global warming

- The Amazon is a **critical carbon sink**.
- Currently, the world is emitting around **40 billion tons of CO_2** into the atmosphere every year.
- **The Amazon absorbs 2 billion tons of CO_2 per year (or 5% of annual emissions)**.
- The fires have not only turned the Amazon into a **temporary carbon source** but also **reduced its potential to lock carbon in the future**.

Forest fires intensify droughts

- The rainforest recycles its own water to produce a portion of the region's rain, so deforestation makes rains less frequent, extending the dry season.

Pollution and Global Warming

- Forest fires cause **15% of GHG emissions, more than 30% of global carbon monoxide emissions, 10% of methane emissions** and more than **85% of global soot emissions**.
- They contribute greatly to global warming, which in turn leads to forests becoming increasingly dry and weak. This destructive cycle often makes it easy for new fires to develop.

Forest Fires and Droughts Make Way for Grasslands (Decrease in Productivity)

- Scientists describe tropical rainforests as "**fire-sensitive ecosystems**."
- About a third of all ecosystems worldwide are considered "fire-sensitive."
- The plants and animals **lack a natural ability to resist and recover from fires**.
- In a rainforest-like the Amazon, massive forest fires are a disaster.
- Despite the lush vegetation, the **soils are particularly barren and poor in nutrients (due to leaching)**.
- If the rainforest burns down, **all nutrients are permanently lost (no recycling of nutrients) because they are stored in the plants themselves and not in the soil**.
- When the rainforests reach their tipping point, they will be unable to sustain themselves.
- This will lead to a situation when the trees, and in turn, the forest will start to **dieback**.
- In other words, some trees and eventually the forests will reach the physiological limits of dryness.
- Because of the dehydration, the trees will begin to **die from the tip of their leaves or roots backwards**.
- The fires combined with prolonged droughts can turn the jungle into a tropical savannah (grassland).
- **The grass** is a **dominant species** that **can grow even in poorer soil**. It does not make way for trees so easily.

Fore fires are essential for other Ecosystems

- While forest fires are a disaster to rainforests, they are **necessary** for the **preservation** of other ecosystems.
- This is true for about three-quarters of all habitats worldwide, including the
  - ✓ **taiga (extremely fire-prone in the dry season)**,
  - ✓ **African savannahs**, the **South Asian monsoon and dry forests**,
  - ✓ **Californian coniferous forests (extremely fire-prone in the dry season)**,
  - ✓ **Australian eucalyptus forests** & the **Mediterranean region** (extremely fire-prone in the dry season).
- In these ecosystems, parts of the natural fauna and flora develop only due to fires.
- Animals and plants often have a natural capacity for resistance in such fire-dependent ecosystems.
- In **grasslands, savannahs, some forests, and wetlands**, **only a moderately intense ground fire sweeps through**, ensuring that the open landscape structure is maintained.
- Rare but very intense fires are characteristic of bush landscapes or forests. They consume old and diseased trees, create new habitats and ensure an **ecological rejuvenation** of the tree population.

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- Preventing small fires in these ecosystems can have fatal consequences. This is because of the accumulation of more combustible material, which converts even harmless fires into destructive walls of flames.
- This repeatedly occurs in the **boreal forests (Siberian taiga and Canadian taiga), forests of Eastern Australia** and **Forests of California (US)**.
- E.g., the **2019-20 Australian Black Summer Bushfires** (caused by successive droughts) and **2021 July wildfires triggered by severe heatwave (caused by a heat dome created by the meandering jet stream)** in the **North-Western US and South-Western Canada**.

Fires give new life

- The Douglas fir, a conifer, survives most fires thanks to its thick bark — after a fire, it will sprout new shoots.
- The North American lodgepole pine also needs the heat of the fire to open its cones and release seeds.
- The Australian grass tree needs smoke to open its seed pods.
- After a fire, without the usually dense canopy, more sunlight reaches the forest floor, and the seedlings find enough nutrients to sprout. (**Small fires are good for even rainforests**).
- Even some insect species need fire to survive.

Threats: Plantation Boom, Resource Extraction

- Petroleum extraction has caused a great deal of destruction in the rainforests of **Ecuador** and **Venezuela**.
- The rainforest climate is very favourable for the cultivation of certain high-value plantation crops.
- The plantations destroyed nearly half of equatorial forests and continue to destroy them even today.

Plantations	Region(s)
Palm	**Malaysia, Indonesia**
Sugarcane	**Brazil**
Coffee	**Brazil**
Rubber	**Malaysia, Indonesia**
Cocoa (used to make chocolates)	**Ghana, Nigeria**

Palm plantations in Indonesia

Effects of Destroying Rainforests

Soil Degradation

- The soil in the rainforest is very poor in nutrients (because of the **leaching of the nutrients** from the top layer).
- This is because the **nutrients are stored** in the **vast numbers of trees and plants rather than in the soil**.
- Tree roots bind the soil together, while the **canopy protects the soil from heavy rains**.
- When a tree dies, and its trunk falls to the forest floor, it decays, and the nutrients it contains are recycled.
- However, if trees are removed from the forest, the nutrients are removed with it.
- The unprotected soil is then simply washed away in heavy rains.

Droughts and famine

- Without rainforests continually recycling huge quantities of water, feeding the rivers, lakes and irrigation systems, droughts would become more common, potentially leading to widespread famine and disease.

Even commercial plantation crops would fail in the long run

- The plantation crops thrive in the tropics because of the **conducive climatic conditions** created by the rainforests.

Extinction of indigenous communities

- When oil and logging companies come to remove vast areas of forest, they bring **diseases** that the indigenous people have no resistance to, threatening their survival.

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- Often, they are also forced to move away from their homes to unfamiliar places, sometimes even being killed in the process.

Q. Which of the following is/are unique characteristic/characteristics of equatorial forests?

1) Presence of tall, closely set trees with crowns forming a continuous canopy.
2) Coexistence of a large number of species
3) Presence of numerous varieties of epiphytes

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: every single statement is correct

7.1.12. Desert Biome

- The predominant vegetation of both hot and mid-latitude deserts is **xerophytic or drought-resistant**.
- This includes the cacti, thorny bushes, long-rooted wiry grasses and scattered dwarf acacias.
- Most desert shrubs have **long roots & are well spaced out** to gather moisture & search for groundwater.
- Plants have **few or no leaves, and the foliage is either waxy, leathery, hairy, or needle-shaped to reduce the loss of water through transpiration**.
- The seeds of many species of grasses and herbs have **thick, tough skins** to protect them while they lie dormant.

7.2. Aquatic Ecosystems

- Aquatic ecosystems refer to plant and animal communities occurring in water bodies.
- Aquatic ecosystems are classified into two subgroups: 1) Freshwater ecosystems, such as rivers, lakes and ponds; 2) Marine ecosystems, such as oceans, estuary and mangroves.
- Aquatic ecosystems are classified on the basis of salinity into the following types:
  1. **Freshwater ecosystems:** water on land that is continuously cycling and has low salt content (**always less than 5 ppt**) is known as freshwater.
     - ✓ There are two types of freshwater ecosystems: 1) **Static or still water (Lentic) ecosystems**, e.g. pond, lake, bogs and swamps. 2) **Running water (Lotic) ecosystems**, e.g. springs, mountain brooks, streams and rivers.
  2. **Marine ecosystems:** the water bodies containing salt concentration equal to or above that of seawater (i.e., **35 ppt or above**). E.g., shallow seas and open ocean.
  3. **Brackish water ecosystems:** these water bodies have salt content in between **5 to 35 ppt**. e.g., **estuaries, salt marshes, mangrove swamps and forests**.

7.2.1. Aquatic Organisms

- The aquatic organisms are classified on the basis of their zone of occurrence.
- **Neuston:** These organisms live at the air-water interface, e.g. floating plants.
- **Periphyton:** These are organisms that remain attached to stems and leaves of rooted plants or substances emerging above the bottom mud, such as sessile algae.

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- **Plankton:** Microscopic floating organisms such as **algae, diatoms, protozoans** and larval forms are called plankton. This group includes both microscopic plants like **algae (phytoplankton – primary producers)** and **animals like crustaceans and protozoans (zooplankton – heterotrophs)**.
- The **locomotory power of the planktons is limited** so that their distribution is controlled, essentially, by **currents** in the aquatic ecosystems.
- **Nekton:** This group contains powerful swimmers that can overcome the water currents.
- **Benthos:** The benthic organisms are those found living at the bottom of the water mass.

7.2.2. Factors Limiting the Productivity of Aquatic Habitats

- Sunlight and oxygen are the most important limiting factors of aquatic ecosystems.

Sunlight

- Sunlight penetration rapidly diminishes as it passes down the column of water.
- The depth to which light penetrates a lake determines the extent of plant distribution.
- Suspended particulate matters such as clay, silt, phytoplankton, etc., make the water turbid.
- **Turbidity** limits the extent of light penetration and photosynthetic activity in a significant way.
- Based on light penetration and plant distribution, they are classified as **photic and aphotic zones**.

Photic zone

- **Photic (or "euphotic") zone** is the portion that extends from the lake surface down to where the light level is **1% of that at the surface**.
- The depth of this zone depends on the transparency of water.
- **Photosynthetic** activity is confined to the **photic zone**.
- **Both photosynthesis and respiration** activity takes place in the photic zone.

Aphotic zone

- The lower layers of the aquatic ecosystems, where light penetration and plant growth are restricted forms the **aphotic zone (profundal zone)**.
- **Only respiration** activity takes place in this zone.
- The aphotic zone extends from the end of the photic zones to the bottom of the lake.

Dissolved oxygen

- In freshwater, the average concentration of dissolved oxygen is **10 parts per million by weight**.
- This is **150 times lower** than the concentration of oxygen in an equivalent volume of air.
- Oxygen enters the aquatic ecosystem through the **air-water interface** and by the **photosynthetic activities** of aquatic plants.
- Dissolved oxygen escapes the water body through the **air-water interface** and **respiration** decomposition of organisms (fish, decomposers, zooplankton, etc.).
- The amount of dissolved oxygen retained in water is also influenced by **temperature**.
- **Oxygen is less soluble in warm water (impact of global warming)**.
- Warm water also **enhances decomposer activity**.
- Therefore, **increasing the temperature of a water body increases the rate at which oxygen is depleted** from the water.
- When the dissolved oxygen level falls **below 3-5 ppm**, many aquatic organisms are likely to die.

Winterkill

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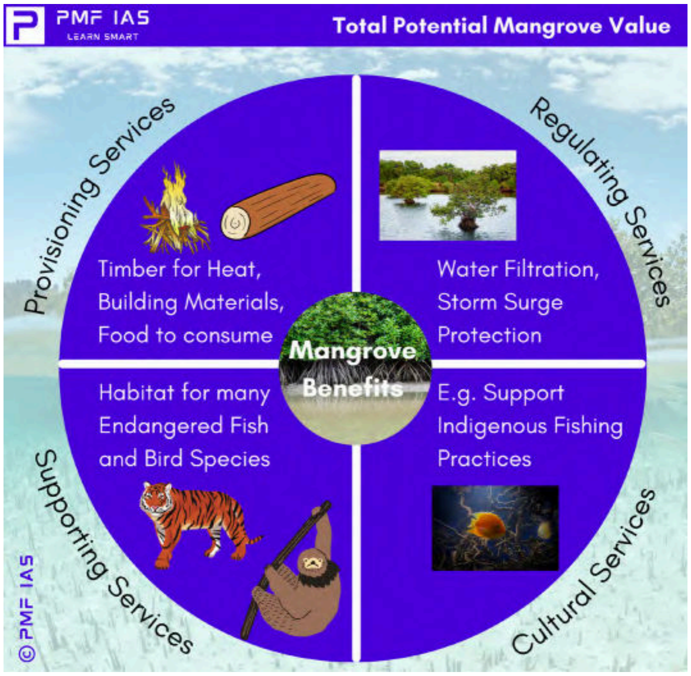
- An ice layer on the top of a water body can effectively cut off the light.
- Photosynthesis stops, but respiration continues in such a water body.
- If the water body is shallow, the oxygen gets depleted, and the fish die.
- This condition is known as **winterkill**.

Temperature

- Since water temperatures are less subject to change, the aquatic organisms have a **narrow temperature tolerance limit**.
- As a result, **even small changes in water temperature are a great threat to the survival of aquatic organisms** when compared to the changes in air temperatures in terrestrial organisms.

7.3. Ecosystem Services & Goods

- **Ecosystem services** are the diverse benefits provided to humans by the natural environment and from healthy eco-systems.
- **Ecosystem goods** refer to the natural products harvested by humans from the environment, such as wild fruit and nuts, forage, timber, game, natural fibres, medicines and so on.
- The ecosystem services can be grouped under the following broad categories:
  - ✓ **cultural (tourism, recreation, etc.),**
  - ✓ **provisioning (food, drinking water, genetic resources, medicinal herbs, energy from biomass, etc.)**
  - ✓ **economic (crops, raw material, etc.),** and
  - ✓ **regulating (carbon sequestration, decomposition, detoxification, healthy biodiversity, climate stabilization, reducing the risk of extreme weather events, etc.)**
  - ✓ **ecological (nutrient cycling, breakdown of pollutants and waste, flood protection, generation and renewal of soils etc.)**



7.3.1. Quantifying the Economic Value of Natural Ecosystems (Ecosystem valuation)

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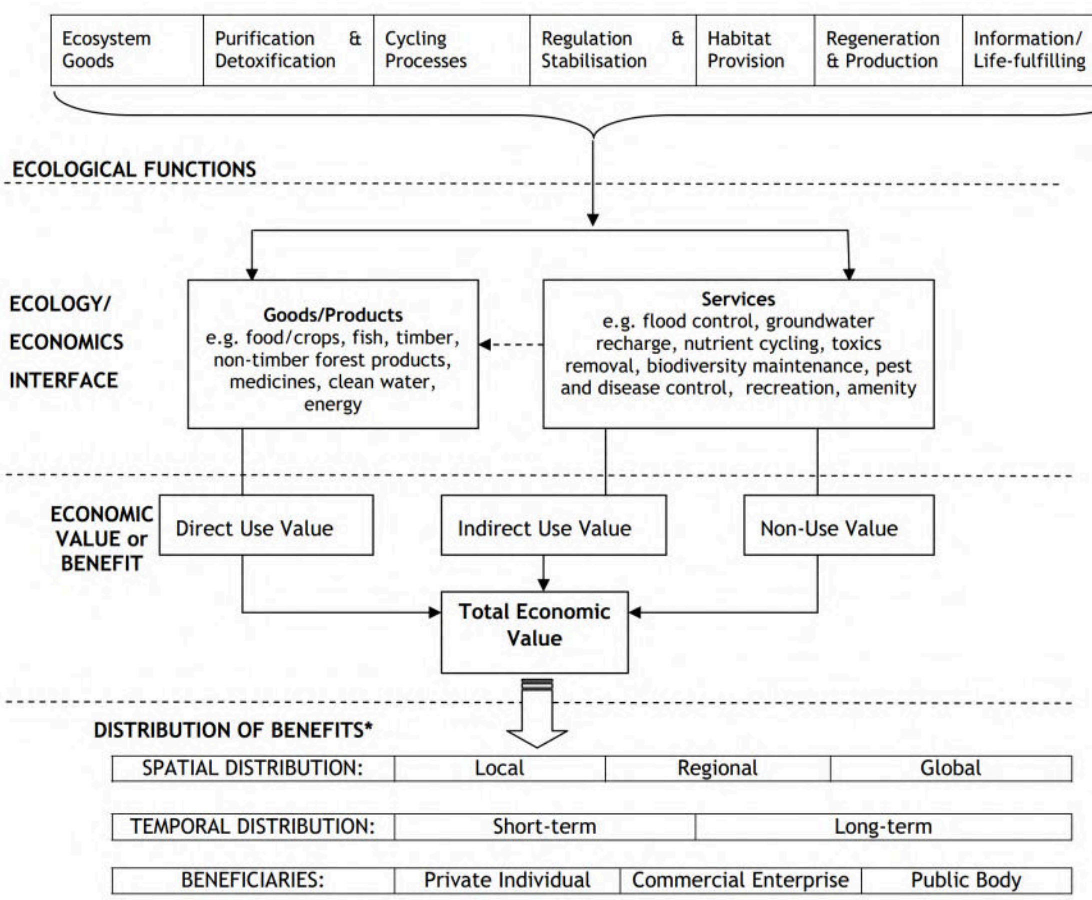

- **Ecosystem valuation** is an economic process that **assigns a monetary value** (or some other value) to an ecosystem and its ecosystem services.
- Quantifying the economic value of natural ecosystems provides a tool for policymakers and conservationists to evaluate management impacts and compare a **cost-benefit analysis** of potential policies.
- For example, before replacing a forest with industry, taking into consideration the human welfare benefits of a forest — to reduce flooding and erosion while sequestering carbon, providing habitat for endangered species, and absorbing harmful chemicals — will help policymakers make better cost-benefit analysis and a better final decision.

7.3.2. The Economics of Ecosystems and Biodiversity (TEEB)

- TEEB was a study hosted by **UNEP** & led by **Indian environmental economist Pavan Sukhdev**.
- One of the motives for the study was to establish a global standard for **natural capital accounting**.
- TEEB, as a global initiative, is focused on "**making nature's values visible (economic benefits of biodiversity)**" and **preserving the natural capital**.
  - ⇨ ***Natural Capital: healthy ecosystem providing invaluable ecosystem services. E.g., Mangroves providing flood protection.***
- TEED's principal objective is to **mainstream the values of biodiversity** and **ecosystem services** into **decision-making at all levels**.
- Its other objective is to highlight the **growing cost of biodiversity loss** and **ecosystem degradation** and to draw together expertise from the fields of science, economics and policy to enable practical actions.

Q. With reference to an initiative called 'The Economics of Ecosystems and Biodiversity (TEEB)', which of the following statements is/are correct? (2016)

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1) It is an initiative hosted by UNEP, IMF and World Economic Forum.
2) It is a global initiative that focuses on drawing attention to the economic benefits of biodiversity.
3) It presents an approach that can help decision-makers recognize, demonstrate and capture the value of ecosystems and biodiversity.

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: Statement 1) is false; d) 2 and 3 only

- TEEB's approach is guided by three principles:
  1. **Recognizing the value in ecosystems** and other aspects of biodiversity. For example, the existence of **sacred groves in some cultures** has helped to protect natural areas and the biodiversity they contain.
  2. **Demonstrating value in economic terms** is often useful for decision-makers to consider the full costs and benefits of nature rather than just those that enter the markets in the form of private goods. An example would include calculating the values of conserving the ecosystem services provided by **wetlands in controlling floods**, as compared to **building flood defences**.
  3. **Capturing value** involves the introduction of mechanisms that incorporate the values of biodiversity and ecosystems into decision-making through **incentives**. This can include **payments for ecosystem services**, **reforming environmentally harmful subsidies** or **introducing tax breaks for conservation**.

Tyler Prize for Environmental Achievement

- The **2020 Tyler Prize for Environmental Achievement was awarded to Pavan Sukhdev** in recognition of his work on the first report of **The Economics of Ecosystems and Biodiversity (TEEB)** published in 2008.
- Following the 2008 report, the UN-appointed Sukhdev to lead the **UNEP's** '**Green Economy Initiative**'.
- The Tyler Prize is an annual award for environmental science, environmental health, and energy.
- Tyler Laureates receive a $200,000 cash prize and a medallion.
- The prize is administered by the **University of Southern California**.

7.3.3. Payment for Ecosystem Services (PES)

- The Himalayan states have been demanding a '**green bonus**' for keeping critical ecosystems intact.
- These states have been getting incentives based on their **forest cover** under a formula by the Finance Commission.
- This sort of incentive called **payment for ecosystems services (PES)** is an **emerging global demand to conserve ecosystems**.
- The 12th FC (2005-10), earmarked Rs 1,000 crores for five years to be given to states for preserving forests.
- The 13th FC allocated Rs 5,000 crore, based on the area under forest cover and Canopy density.
- The 14th FC included forest cover as a determining factor in a state's share.
- In the distribution of funds to states, the commission attached a 7.5 per cent weight to forest cover.
- Population, demographic change, area are the other factors that decide the share in the central tax pool.
- But the Himalayan states have not been a clear winner under this arrangement as they have not received their due share.

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Ecological services offered by the Himalayan States

- Himalayan states have a forest in around 41.5 per cent of their geographical area — a third of the country's forest cover, according to the **National Mission for Sustaining Himalayan Ecosystems (NAPCC)**.
- The total value of forest ecosystem services flowing from the Indian Himalayan level, it is Rs 94,300 crore / year.
- They are one of India's major **carbon sink**. Estimates of forest carbon pool in Indian Himalaya is about 5.4 billion tonnes (forest biomass + forest soil).
- They avert soil erosion from the world's youngest mountain range.
- These states can be termed as the water reservoir of the country. Annually, 1,200 billion cubic metres of water flow through the Himalayan rivers.
- So, these states, by protecting forests (sacrificing development), ensure life-saving services to the country.
- Hence, they truly deserve a **'green bonus' (payment for ecosystem services)** proportional to the economic sacrifices made and conservation costs incurred.

Incentivising Climate-Resistant Agriculture

- In the climate change regime, carbon emission reduction activities do huge businesses.
- But agriculture has been kept out of the formal carbon market that is worth more than $100 billion.
- Farmers, particularly those practising traditional farming, including in Himalayan states, have been rarely considered eligible for payment for their ecological services.
- Now, it is being felt that farmers (practising climate-resistant traditional farming) should be rewarded for their ecological services.

Global scenario

- Globally, the services an ecosystem provides are getting increasing policy attention.
- In 2010, the Conference of Parties to the **Convention on Biological Diversity held in Nagoya** accepted '**environmental goods part of the national accounts (the monetary value of ecological services)**.'
- PES is fast turning into a mode of conservation, even though not that wide in India.
- At present, ecological services payment schemes cover **carbon sequestration and storage**, **watershed development and protection**, non-domestic **biodiversity protection** and forest protection.

Amazon Fund

- Globally, there is tremendous momentum to save the Amazon forests.
- There is a **billion-dollar Amazon Fund** backed by **Norway** (petroleum exporter) and **Germany**.
- The Amazon Fund is a **REDD+ mechanism** created to raise donations for investments in efforts to prevent, monitor and combat deforestation, as well as to promote sustainable use in the Brazilian Amazon.
- The Amazon Fund is managed by **Brazilian Development Bank**.
- The Brazilian government wants to alter the governance model for the Amazon fund and **wants to exploit forest resources and use forest land for economic development**.
- Norway and Germany are against such a decision.

7.3.4. Ecosystem Services by Seagrass

- Seagrass (they are **not** grass, as the name suggests) are **aquatic** flowering plants **(angiosperms)**.
- The depth at which seagrass are found is limited by **turbidity** (determines the amount of light reaching the plant and hence the photosynthesis).

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- Seagrasses are found in **shallow salty and brackish waters** in many parts of the world, from the **tropics to the Arctic Circle**.
- Seagrasses are considered **ecosystem engineers** (alter the ecosystem around them and adapt rapidly to changing environmental conditions).
- Seagrasses occur all along with the **coast of India**.
- They are **abundant in the Palk Strait & Gulf of Mannar in Tamil Nadu.**

Importance of Seagrass

- They can **store CO_2** using their own biomass as well as by filtering out fine organic material in water.
- An acre of seagrass can store about **three times as much carbon as an acre of rainforest**.
- Globally, seagrass meadows are responsible for more than **10 per cent of carbon buried in the ocean**, even though they occupy just **0.2 per cent of the area**.
- Seagrass **produces oxygen** and are **highly productive,** and support a high diversity of organisms.
- The habitats act as **nursery grounds** for commercially and recreationally (tourism) valued fishery species.
- They dissipate wave energy, thereby **protecting vulnerable shorelines from erosion**.
- Large meadows of seagrass can help protect seawalls by adequate damping of waves.
- They **enhance water quality** by stabilizing heavy metals, pollutants, and excess nutrients,
- Historically, seagrasses were collected as **fertilizer for sandy soil**.
- They can trap fine sediment on the seabed and **prevent harmful algal blooms (eutrophication)**.
- Coastal lines facing threats from rising sea levels can be protected by seagrass.
- **Dugong or Sea Cow (VU)** is a **herbivorous marine mammal** that relies on seagrass for food.

Q. With reference to 'dugong', a mammal found in India, which of the following statements is/are correct?

1. It is an herbivorous marine animal.
2. It is found along the entire coast of India.
3. It is given legal protection under Schedule I of the Wildlife (Protection) Act, 1972.

Select the correct answer using the code given below.

a) 1 & 2
b) 2 only
c) 1 & 3
d) 3 only

Explanation:

- The dugong is a herbivorous mammal. It eats seagrass & aquatic plants found in shallow oceans (at depths, seagrass & aquatic plants don't grow due to the absence of sunlight).
- In India, its range is limited to the **south (Palk Strait & Gulf of Mannar)** and **west coast (Gulf of Kutch)**.
- The depletion of seagrass resources on the east coast has made the dugong locally extinct.

Wildlife (Protection) Act, 1972

- Harming endangered (vulnerable, endangered, critically endangered) species listed in Schedule 1 of the Act is prohibited throughout India.
- Hunting species, like those requiring special protection (Schedule II), big game (Schedule III), & small game (Schedule IV), is regulated through licensing.
- A few species classified as vermin (Schedule V) may be hunted without restrictions.

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Answer: c) 1 & 3

Threats faced by seagrass

- Natural disturbances, such as grazing, storms, desiccation.
- Human disturbance: eutrophication, mechanical destruction of habitat, and overfishing.

Eutrophication

- Excessive input of nutrients (**nitrogen, phosphorus**) is directly toxic to seagrasses.
- Excessive nutrients stimulate the growth of **epiphytic and free-floating macro- and micro-algae**.
- **Macroalgae (nuisance species**) form thick unattached mats or epiphytes over seagrass leaves.
- This **increases turbidity** (loss of transparency), reducing the photosynthesis in seagrass (primary producer).
- **Benthic (bottom) macroalgae** have low carbon/nitrogen content, causing their **decomposition** to stimulate bacterial activity, leading to sediment resuspension, a further increase in water turbidity.
- Decaying seagrass leaves and algae fuels increasing **algal blooms (algae starts to dominate seagrass)**.
- **Eutrophication** eventually leads to anoxic conditions for the seagrass and organisms around.

7.3.5. Ecosystem Services by Seaweed

- **Seagrasses** are **vascular plants** and have roots, stems and leaves. In comparison, seaweed is the common name for species of **primitive non-flowering marine plants (without roots, vascular system, stem & leaves), microalgae & macroalgae**.
- They **grow in shallow waters in the tidal zone** (intertidal region) & also in estuaries & backwaters.
- Some seaweeds are microscopic, such as the **phytoplankton** that lives suspended in the water column.
- Some are enormous, like the **giant kelp** that grow in abundant "forests" from their roots at the bottom.

Commercial Significance

- Seaweed is **full of vitamins, minerals, & fibre.**
- Many seaweeds contain anti-inflammatory & anti-microbial agents. Certain seaweeds possess powerful **cancer-fighting agents**.
- They are effective **binding agents (emulsifiers)** & are used in commercial goods like **toothpaste, fruit jelly, ice cream** & **popular softeners (emollients) in organic cosmetics & skin-care products**.

Ecological Importance of Seaweed Cultivation

Treating coastal pollution

- Seaweeds absorb the excess nutrients & **reduce algal blooms**.
- Seaweeds **use iron for photosynthesis**. Seaweeds hence trap excess levels of iron in the water.
- Similarly, most **heavy metals f**ound in marine ecosystems are removed by seaweeds.

Oxygen & Nutrient Supply

- Seaweeds supply oxygen & organic nutrients to other marine life forms.
- Large seaweeds form **dense underwater forests** known as **kelp forests** which act as **underwater nurseries** for fish & other marine life forms.

Mitigating climate change through Ocean Macroalgal Afforestation (OMA)

- Seaweeds exhibit **the highest photosynthesis efficiency** due to moist conditions.
- They contribute to about **50% of all photosynthesis** in the world.

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- Hence, seaweed farming is the ideal prospect for **Ocean Macroalgal Afforestation (OMA)**.
- **Ocean Afforestation** has the potential to reduce atmospheric carbon dioxide concentrations through expanding natural populations of **macroalgae (seaweed), which absorb carbon dioxide**.
- Seaweed can then be harvested to produce **biomethane** via **anaerobic digestion**.

Other Utilities

- They can be used as **fertilizers** in aquaculture.
- Methane emission from cattle may be reduced substantially if seaweed is used as feed.
- Seaweed can be very helpful to combat beach erosion.

Seaweed Cultivation: Potential in India

- **India is among the 12 mega-biodiversity nations in the world**.
- India has an **Exclusive Economic Zone (EEZ) of 2.17 million km^2**.
- The Indian coastline, with its different coastal ecosystems, **supports the luxuriant growth of diverse seaweed** populations, having considerable economic importance.
- About 844 seaweed species are reported from India, which has a **coastline of 7,500 km**.
- On the **West Coast, especially in Gujarat**, abundant resources are present in the intertidal & subtidal regions.
- These resources have **great potential for the development of seaweed-based industries in India**.
- **Tamil Nadu, Gujarat coasts, Lakshadweep & Andaman & Nicobar Islands** are abundant in seaweed.
- Rich seaweed beds are also found around Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam & Pulicat in Tamil Nadu & Chilka in Orissa.
- The southern Gulf of Mannar's intertidal region is home to more than 240 seaweed varieties, out of which at least 185 are edible ones.

Challenges to seaweed harvesting in India

- Seaweed cultivation in India remains unpopular. Labour shortages occur during the paddy harvesting & transplanting season.
- Lack of livelihood security due to low wages & bad weather.
- Lack of technology to improve processed products.
- Lack of information on new & alternative sources of raw material.
- Risky as they must be collected from depths of more than 25 to 30 feet.
- Over-exploitation: While India has a rich source of seaweed varieties, we have **focused only on harvesting & not cultivation**, thus leading to over-exploitation.
- Less market demand: lack of awareness about health benefits act as a hindrance to nutrition transition among the population.

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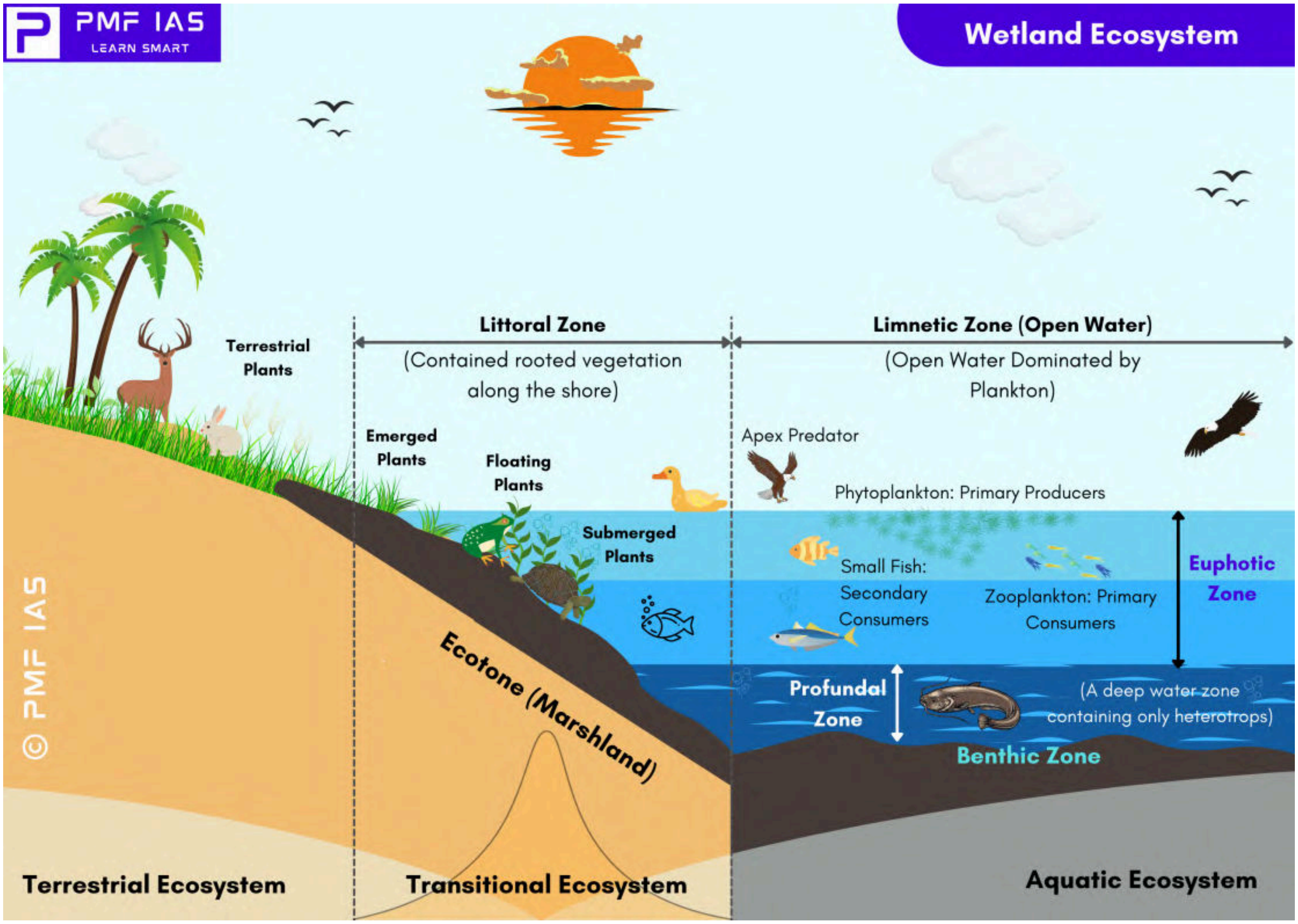

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8. Wetland Ecosystem

- Wetlands are **areas of marsh or peatland** with water that is static or flowing, fresh, brackish or saline, including areas of marine water, the **depth of which at low tide does not exceed 6 m**.
- Wetlands are **transition zones (ecotone)** between **terrestrial and aquatic ecosystems**.
- E.g., **Mangroves, lake littorals** (marginal areas between highest and lowest water level of the lakes), **floodplains** (areas lying adjacent to the river channels beyond the natural levees and periodically flooded during high discharge in the river) and other marshy or swampy areas.
- These habitats experience periodic flooding from adjacent deepwater habitats and therefore supports plants and animals specifically adapted to such **shallow flooding or waterlogging**.
- Waterlogged soil adapted plant life (**hydrophytes**) and **hydric soils (not enough O_2)** are the chief characteristics of wetlands.
- India has over 27,000 wetlands (18.4% of total area), of which 23,000+ are inland wetlands, and around 4000 are coastal wetlands.
- Wetlands occupy 18.4% of the country's area, of which **70% are under paddy cultivation (human-made)**.
- Natural wetlands in India range from high altitude wetlands in the Himalayas; flood plains of the major river systems; saline and temporary wetlands of the arid and semi-arid regions; coastal wetlands such as lagoons, backwaters, estuaries, mangroves, swamps and coral reefs, and so on.

8.1. Differences Between Wetlands and Lakes

- **Lakes are generally less important** when compared to the wetland from the viewpoint of ecosystem and biodiversity conservation.
- There is no clear distinction between lakes and wetlands. **Wetlands** are **shallow water bodies,** whereas lakes can be deep or shallow.
- **National Lake Conservation Programme (NLCP)** considers lakes as standing water bodies that have a minimum water depth of **3 m**, generally cover a water spread of **more than ten hectares** and have **no or very little aquatic vegetation**.
- Wetlands (**generally less than 3 m deep over most of their area**) are usually **rich in nutrients** (derived from surroundings and their sediments) and have **abundant growth of aquatic macrophytes (an aquatic plant large enough to be seen by the naked eye)**.
- They **support high densities and diverse fauna**, particularly birds, fish and macroinvertebrates, and therefore, have high value for biodiversity conservation.
- **Excessive growth of macrophytes** (both submerged and free-floating) in wetlands affects the water quality adversely and interfere with the utilization of the water body.
- However, marginal aquatic vegetation is desirable as it checks erosion, serves habitat for wildlife and helps improve water quality.

Characteristic	Lake	Wetland (shallow lake)
Origin	• Largest is due to tectonic forces: Fluvial, geomorphic, increase in the water table, etc.	• Mostly fluvial, residual lakes. • E.g., **Kolleru Lake** in Andhra Pradesh
Water turnover	• Permanent	• Permanent or Temporary
Water level changes	• Relatively small	• Relatively Large

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Thermal stratification	• Yes	• No
Vertical mixing	• Thermally regulated (because of depth)	• Wind regulated
Dominant Producer	• **Phytoplankton**	• **Macrophytes**
Food chain	• **Grazing Pathway**	• **Detritus Pathway**
Productivity	• **Low**	• **High**
Trophic status	• **Oligotrophic (low nutrient levels; low turbidity; low sedimentation; low population density; low diversity)**	• **Mostly Eutrophic (high nutrient levels; high turbidity; high sedimentation; high population density; high diversity)**
Flood control	• Less Significant	• Significant
Waste treatment	• No	• Yes

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8.2. Estuarine Wetland Ecosystem

- An estuary is a place where a **river or a stream opens into the sea (mouth of the river)**.
- It is a **partially enclosed** coastal area of **brackish water** (salinity varies between **0-35 ppt**) with one or more rivers or streams flowing into it and with a free connection to the open sea.
- At the estuaries, freshwater carrying fertile silt and runoff from the land mixes with the salty seawater.
- Estuaries form a **transition zone (ecotone)** between river environments and maritime environments.
- Examples of estuaries are **river mouths, coastal bays, tidal marshes, lagoons, and deltas**.

- Estuaries are formed due to the **rise in sea level, movement of sand and sandbars, glacial processes** and **tectonic processes**.
- All the plants and animals in the estuaries are subjected to variations in salinity to which they are adapted (**osmo-regulation**).
- Estuaries are **greatly influenced by tidal action**. They are periodically washed by seawater once or twice a day based on the number of tides.
- In some narrow estuaries, tidal bores are significant.
- **Tidal bores cause significant damage to the estuarine ecology**.

8.2.1. Importance of Estuaries

Ecological Importance

- **Estuaries (coastal wetlands)** are the **most productive** (**more productive than wetlands**) water bodies in the world because of the **mixing of freshwater and saline water zone** where **marine organisms of both ecosystems meet**.
- An estuary has **very little wave action**, so it provides a calm refuge from the open sea and hence becomes **ideal for the survival of numerous aquatic species**.
- The vast **mangrove forests** on the seaward side of an estuary act as a **barrier for the coastal habitat** to check the wind speed during cyclones and high velocity landward winds.
- **Mangroves act as a filter trapping suspended mud** and sand carried by rivers which leads to delta formations around estuaries.
- **Precipitation of clay and alluvium particles in the estuarine region is high** because of **exposure to saline water (saline water precipitates fine alluvium)**.
- Estuaries **store and recycle nutrients**, traps sediment and forms a **buffer** between coastal catchments and the marine environment.
- They also absorb, trap and detoxify pollutants, acting as a natural water filter.

Economic Importance

- Estuaries are the most **heavily populated** areas throughout the world, with about 60% of the world's population living along estuaries and the coast.
- Estuaries with their wetlands, creeks, lagoons, mangroves and **seagrass beds** are rich in natural resources, including **fisheries**.

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- **They are deep and well protected from marine transgressions**, and hence they are **ideal locations for the construction of ports and harbours**.

8.2.2. Differences between Lagoon and Estuary

- A lagoon is a stretch of **saltwater** separated from the sea by a **low sandbank or coral reef**.
- **Backwaters in Kerala** are **primarily lagoons** where seawater flows inwards through a small inlet that is open towards the sea.
- In estuaries, the water flows fast & strong, while **in lagoons, the water is shallower and flows sluggishly**.
- **Estuaries are usually deeper than lagoons**.
- Also, **lagoons mostly do not have any fresh water source,** while the estuaries have at least one.
- Lagoons are more saline than estuaries.
- **Lagoons are formed due to falling in sea levels** (coastline of emergence. **E.g., Kerala Coast**), whereas **estuaries are mainly formed due to rise in sea levels** (coastline of submergence. **E.g., Konkan coast**)

8.2.3. Estuarine Vegetation

- Only certain types of plants & animals adapted to the "**brackish**" estuarine waters flourish in the estuaries.
- Factors influencing the distribution of organisms in an estuary are its **salinity** and the amount of **flooding**.
- Estuaries support diverse habitats, such as **mangroves, salt marshes, seagrass, mudflats** etc.
- Estuaries are **very dynamic and productive ecosystems** since the **river flow, tidal range** and **sediment distribution is continuously changing** in them.
- In general, the **phytoplankton of estuaries are diatoms, dinoflagellates, green algae, blue-green algae**.
- Towards the seacoast of the estuaries, there are **large algae and seagrasses**.
- Near the **mouth of the rivers and deltas**, there are **mangrove forests**.
- Estuaries are homes to all king of terrestrial or land-based plants and animals, such as wood storks, pelicans, coniferous and deciduous trees and butterflies.
- Estuaries are also home to unique aquatic plants and animals, such as **sea turtles, sea lions**, sea catfish, saltworts, eelgrass, salt grasses, cordgrasses, **seagrass**, sedge, bulrush etc.

8.2.4. Indian Estuarine Ecosystem

- The country has 14 major, 44 medium, and 162 minor rivers drains into the sea through various estuaries.
- **Major estuaries occur in the Bay of Bengal**. Many estuaries are locations of some of the **major seaports**.
- Most of India's major estuaries occur on the **east coast**. In contrast, the **estuaries on the west coast are smaller** (**in environmental studies, deltas are considered as subsections of estuaries**).
- Two typical examples of estuaries on the west coast are the **Mandovi** and **Zuari estuaries**.

8.2.5. Issues of Indian Estuarine Ecosystem

- Modifications of the estuarine catchments result in changes in water flow in various estuaries, either far in excess or much lower than required (E.g., Hooghly, Godavari, Pulicat etc.)
- Pollution through industries and combined city sewage discharge.
- Recreational boating and fishing.
- Navigation, **dredging and shipping** (e.g. **Hooghly**).
- Expansion of urban and rural settlements, mining & industries, agriculture and dumping of solid wastes.
- Overexploitation of target fish stock.
- Reclaiming the fringed areas for **intensive aquaculture** in pens.

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- **Obstructing the migratory routes of fish and prawn recruitment** (e.g., Chilka, Pulicat).
- Polluting the environment through feeding of stocked fish and prawns in pens (Chilka).
- Destruction of biodiversity through prawn seed collection and operation of small-meshed nets (e.g., Hooghly, Chilka, Pulicat).
- Submergence of catchment areas due to rising in water level.

8.3. Mangroves

- Mangroves are **salt-tolerant (halophytes)** shrubs or small trees (vary in height from 8 to 20 m) that represent a characteristic **littoral (near the seashore)** forest ecosystem.
- These are **mostly evergreen forests** that grow in **brackish waters** of **sheltered low-lying coasts, estuaries, mudflats, tidal creeks, backwaters (coastal waters held back on land)**, **marshes** and **lagoons** of **tropical and subtropical regions**.
- Mangroves grow **below the high-water level of spring tides**. The best locations are where **abundant silt** is brought down by rivers or on the backshore of accreting sandy beaches.

8.3.1. Adaptive Mechanism of Mangroves

- Mangroves exhibit varied morphological (shape & structure) and physiological (functions) evolutionary adaptations to survive the limiting factors — **lack of oxygen, high salinity,** and **diurnal tidal inundation**.
- Some of the adaptations exhibited by mangroves**:**
  - ✓ **Succulent leaves** (**thick leaves adopted to store water and reduce evapotranspiration**),
  - ✓ **sunken stomata** (to protect from drying winds),
  - ✓ **leaves with salt-secreting glands** (to flush out the excess salt)
  - ✓ **aerial breathing roots** called '**pneumatophores**',
  - ✓ **vivipary**,
  - ✓ **stilt roots** and
  - ✓ **buttresses (large, wide support roots on all sides of a shallowly rooted (mangrove) tree)**.
- Some species (e.g., **rhizophora**) of mangroves send arching **prop roots** down into the water.
- While others (e.g., **avicennia**) send vertical **"Pneumatophores" or air roots** up from the mud.
- **Adventitious roots** which emerged from the main trunk of a tree above ground level are called **stilt roots**.
- The **pneumatophores (blind roots), prop roots** & **stilt roots** help mangroves **overcome the respiration problem** in the **anaerobic (low oxygen — anoxic) soil** conditions (a classic example of **adaptation**).
- Moreover, the complex root system helps mangroves overcome the strong wave action and **diurnal tidal inundation**.

India's Mangrove Cover Assessment 2019 (area in sq km)

GA: Geographic area in sq km | Numbers not important, but inferences are. Like which state is at top?

S.No.	State/UT	Very Dense Mangrove	Moderately Dense Mangrove	Open Mangrove	Total GA	Change In GA
1.	**Andhra Pradesh**	0.00	**213.00**	191.00	404.00	0.00
2.	Goa	0.00	20.00	6.00	26.00	0.00
3.	**Gujarat**	0.00	**169.00**	**1,008.00**	**1,177.00**	**37.00 ↑**
4.	Karnataka	0.00	2.00	8.00	10.00	0.00
5.	Kerala	0.00	5.00	4.00	9.00	0.00
6.	**Maharashtra**	0.00	88.00	232.00	**320.00**	16.00 ↑

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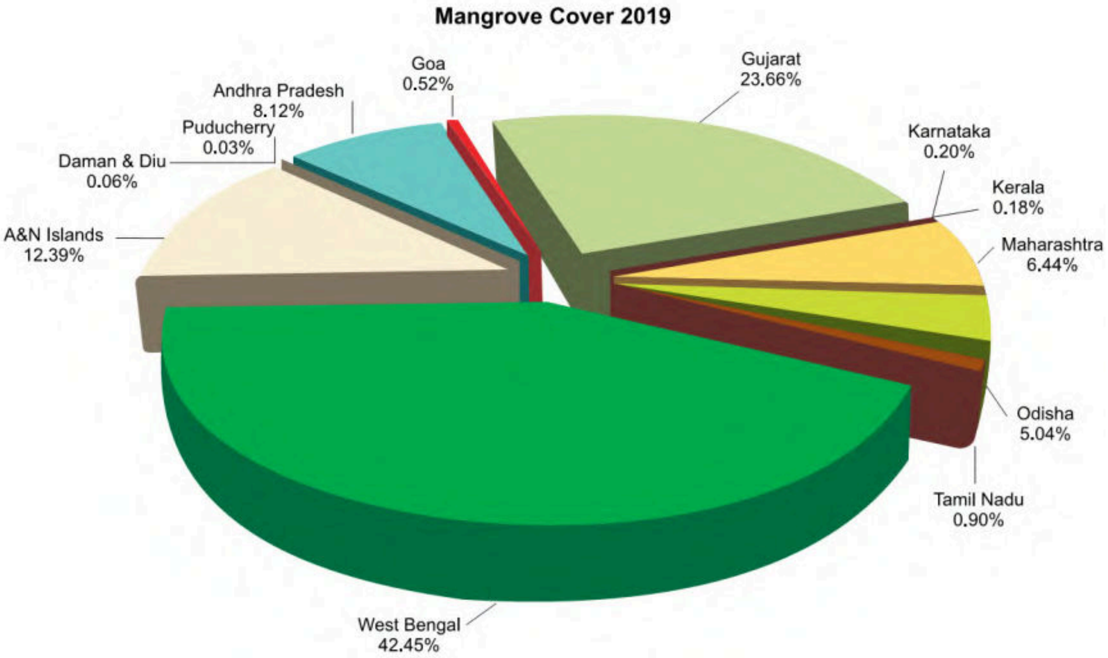
7.	**Odisha**	**81.00**	94.00	76.00	**251.00**	8.00 ↑
8.	Tamil Nadu	1.00	27.00	17.00	45.00	**-4.00** ↓
9.	**West Bengal**	**996.00**	**692.00**	**424.00**	**2,112.00**	**-2.00** ↓
10.	**A&N Islands**	**398.00**	169.00	49.00	**616.00**	**-1.00** ↓
11.	Daman & Diu	0.00	0.00	3.00	3.00	0.00
12.	Puducherry	0.00	0.00	2.00	2.00	0.00
Total		**1,476 (29.66%)**	**1,479 (29.7%)**	**2,020 (40.6%)**	**4,975.00**	**54.00** ↑



- Mangroves exhibit a **viviparity mode of reproduction**. i.e., **seeds germinate in the tree itself** (before falling to the ground).
- This is an **adaptive mechanism** to **overcome the problem of germination in saline water**.

8.3.2. Mangroves in India

- In size, mangroves range from **bushy stands of dwarf mangroves found in the Gulf of Kutch** to **taller stands found in the Sundarbans**.
- On the Andaman & Nicobar Islands, the small tidal estuaries and the lagoons support a dense and diverse undisturbed mangrove flora.

Mangroves of Sundarbans

- Sundarbans has received its name from the Sundari mangrove tree.
- The **mangroves of Sundarbans** are the largest single block of **tidal halophytic** mangroves of the world.
- The **Sundarbans delta**, spread over India and Bangladesh, is the **only mangrove forest in the world inhabited by tigers**.
- **Sundarbans support 400+ tiger population,** of which **88 tigers are in the Indian part** (Census 2018).
- Major fauna of Sundarbans includes **Royal Bengal tiger (EN)**, **saltwater crocodile (LC)**, river terrapin, **olive ridley turtle (VU)**, **Ganges river dolphin (EN)**, hawksbill turtle, mangrove horseshoe crab, etc.
- The eco-geography of this area is totally dependent on the **tidal effect**.
- The tidal action deposits silt back on the channels, raising the bed and forming new islands and creeks.

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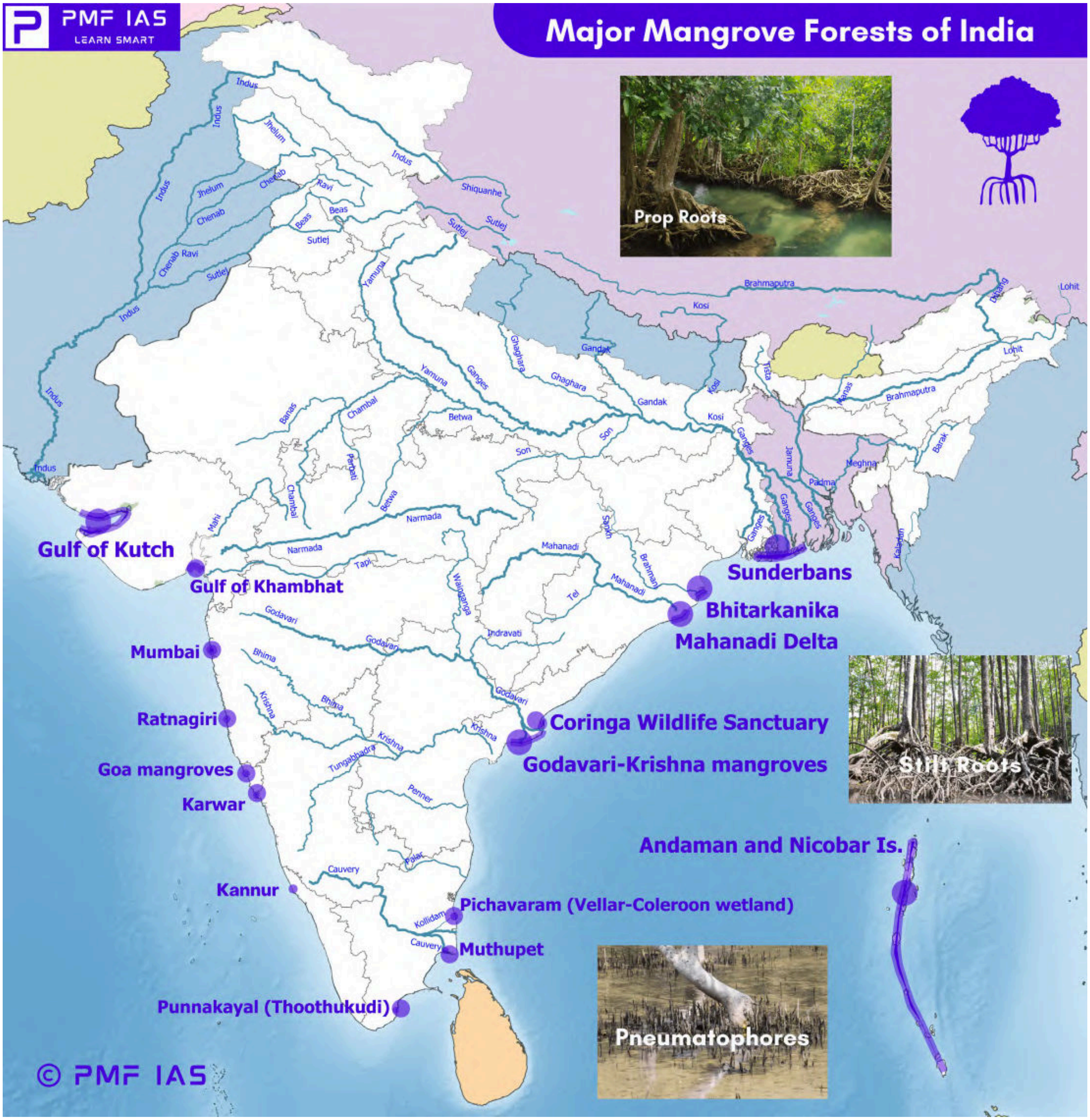

- Mangrove areas here are being cleared for agricultural use.

Bengal tigers may not survive climate change, UN report finds

- 70 per cent of the land in the Sundarbans is just a few feet above sea level.
- In 2010, a study led by the **World Wide Fund for Nature** projected that a sea-level rise of 11 inches could reduce the number of tigers in the Sundarbans by 96 per cent within a few decades.
- Man-animal conflict: Rising sea level will bring tigers in close contact with the human population.

Other major Mangrove Forests on the East Coast

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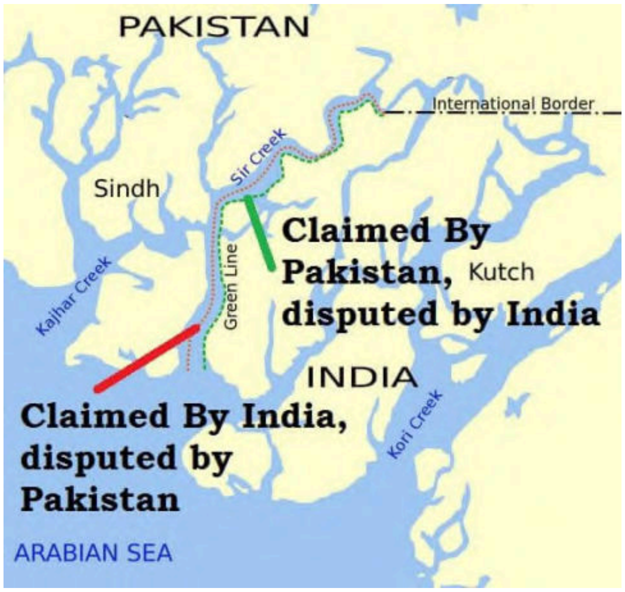
- The mangroves of **Bhitarkanika (Orissa)**, which is the **second largest in the Indian sub-continent**, harbour high concentration of typical mangrove species and high genetic diversity.
- Mangrove swamps occur in profusion in the intertidal mudflats on both sides of the creeks in the **Godavari-Krishna deltaic regions of Andhra Pradesh**.
- Mangroves of **Pichavaram and Vedaranyam** are degraded mainly due to the construction of **aquaculture** ponds and **salt pans**.

Mangrove Forests on the West Coast



Creeks in the Kutch Region

- On the west coast of India, mangroves, mostly scrubby and **degraded,** occur along the intertidal region of **estuaries and creeks** in Maharashtra, Goa and Karnataka.
- The mangrove vegetation in the coastal zone of Kerala is very sparse and thin.
- In Gujarat (north-west coast), mangroves are found mainly in the **Gulf of Kutch and the Kori creek region** (**paleodelta of the Indus River** (once upon a time, it was part of Indus delta)).
- They are of the scrubby type with stunted growth, forming narrow, **discontinuous patches** on soft clayey mud.

Kharai Camel – India's swimming camels

- **India's swimming camels (Kharai Camel)** are endangered by the **destruction of mangroves in Kutch**.
- Since 2015, Kharai camels are getting protection similar to endangered species.
- Kharai camels are dependent on mangroves for their food for eight months of the year.
- During monsoons, they swim to the mangrove islands in hordes.
- Kharai camels are the primary source of livelihood of the **Jat** and **Rabari** communities of the Kutch region.

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Q. What is/are unique about 'Kharai camel', a breed found in India? (2016)

1. It is capable of swimming up to three kilometres in seawater.
2. It survives by grazing on mangroves.
3. It lives in the wild and cannot be domesticated.

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

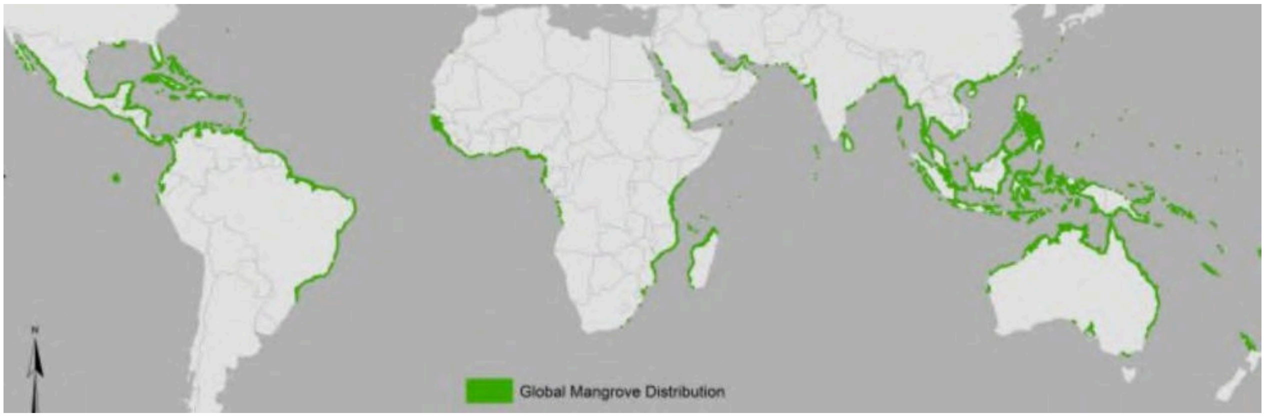
Explanation:

- **Maldharis of the Kutch Region** have developed **tolerant breeds of livestock** such as the **kankrej, the Banni buffalo**, and the **kharai camel**.

Answer: a) 1 and 2 only

8.3.3. Global Status of Mangrove Cover

- Mangroves are mostly distributed over 123 countries in **tropical and sub-tropical regions**.
- The total Mangrove cover in the world is **15 million ha** which is **1% of the Tropical Forests of the World**.
- The mangrove cover in India is **4,975 sq km**, which is **0.15%** of the country's total geographical area.
- **Asia** has the largest extent of the world's mangroves.
- About **40% of the world's Mangrove Cover is found in Southeast Asia and South Asia,** followed by **South America, North Central America** and West and Central Africa.



Why are mangroves not found beyond subtropics?

- Mangroves are confined to **tropics and subtropics**, occurring mainly in the **intertidal regions** between **latitude 24° N and 38° S (ISFR 2019)**.
- This is because the mangroves vegetation contains a **complex salt filtration system** that **facilitates high water loss at the root level itself to cope up** with the brackish conditions.
- These adaptive mechanisms are energy-intensive and **require high solar radiation**.
- This explains why **mangroves are confined to only tropical and subtropical coastal waters**.

8.3.4. Importance of mangroves

- Mangroves are **highly productive ecosystems** with **rich biodiversity**.

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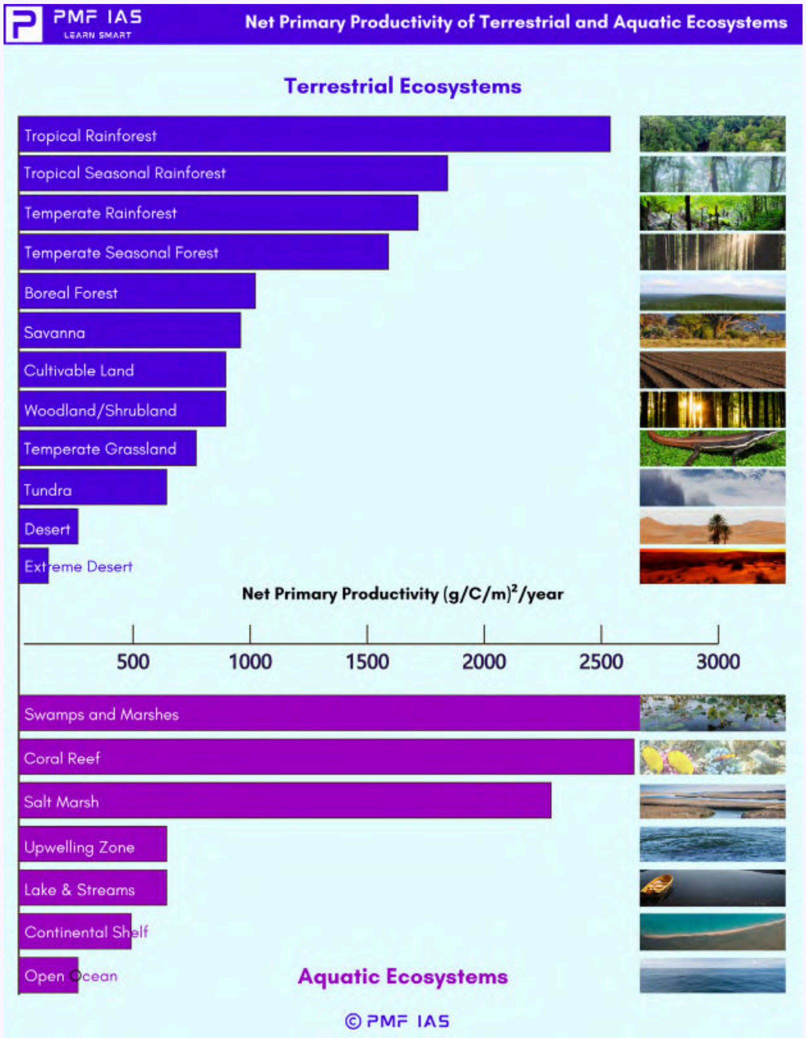
- Since mangroves are located between the land and sea, they represent the best example of **ecotone**.
- Mangroves have a complex root system that is **very efficient in dissipating the sea wave energy,** thus **protecting the coastal areas** from **tsunamis, storm surge (produced by cyclones)** and **soil erosion**.
- Mangroves slow down water flow and act as a **zone of land accretion** by enhancing **sediment deposition**.
- They moderate monsoonal tidal floods and **reduce the inundation** of coastal lowlands.
- They act as a **riparian buffer** and trap pollutants, including **heavy metal contaminants**.
- Mangroves are an important **carbon sink**.
- They enhance the natural recycling of nutrients.
- They provide a safe and favourable environment for breeding, spawning, rearing several fishes.
- They act as an important source of livelihood for the coastal communities dependent on the collection of honey, tannins, wax, firewood, medicinal plants, edible plants and fishing.

Q. Which one of the following is the correct sequence of ecosystems in the order of decreasing productivity?

a) Oceans, lakes, grasslands, mangroves
b) Mangroves, oceans, grasslands, lakes
c) Mangroves, grasslands, lakes, oceans
d) Oceans, mangroves, lakes, grasslands

Explanation:



- Productivity = production/unit area/unit time.

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- Production/unit area depends on the number and diversity of producers.
- **Ecotones (Mangroves, estuaries, and grasslands)** have **greater productivity** compared to the surrounding ecosystems.
- **Tropical Rainforests and coral reefs are an exception as they have productivity comparable to wetlands** because of their rich diversity of primary producers).
- Note: **Grasslands are not transitional all the time**. E.g., Steppe & Savanna grasslands which are very vast, are non-transitional grasslands and have very low productivity because of the very limited diversity of primary producers. (Grasslands become transitional only when they are narrow).
- So, the order of decreasing productivity will be like Mangroves,……, ……, ……..
- Oceans are very deep, and hence productivity is limited to the surface only (deep below in the aphotic zone, productivity is negligible. The Aphotic zone in oceans is a few kilometres thick!).
- Also, **surface water in oceans is very poor in nutrients** (except near the shoreline).
- **Nutrient-rich cold-water flows** as a sub-surface flow lying in the **aphotic zone**.
- Sunlight and nutrients are far apart, and hence **primary productivity is very low** except in regions where there is an **upwelling of nutrient-rich cold water (cold and warm ocean current mixing zones)**.
- So, among the options, the **open ocean ecosystem has the least productivity**. (**Desert ecosystem also has very low productivity, lesser than the oceans**).
- So, the answer will look like Mangroves, ………., ………, Oceans. The only such option is c)
- Lakes, just like oceans, have low productivity. But due to some plants in the photic zone, **lakes have productivity slightly greater than that of oceans**.

Answer: c) Mangroves, grasslands, lakes, oceans

8.3.5. Threats to Mangroves and Associated Consequences

Q. Discuss the causes of depletion of mangroves and explain their importance in maintaining coastal ecology. (2019)

Aquaculture, Agriculture and Salt Ponds

- Agriculture and aquaculture pose the single largest threat to mangroves.

Threat

- Mangroves are ideal locations for shrimp farming and other kinds of mariculture (food production in a confined marine environment).
- They are rich in nutrients and are part of larger wetland systems, which makes them attractive for agriculture.
- Hence thousands of hectares of mangrove forests have been cleared for commercial production of shrimp and other species, cultivate agricultural crops, and creating salt ponds.

Consequences

- The shrimp and other species in the artificial ponds are fed specific diets that often include chemicals.
- The chemicals enter the **food chain** and can harm nearby species.
- Extra nutrients from the concentration of food and animals cause **eutrophication**, which harms the surrounding marine habitats by **lowering oxygen levels**.

Coastal Development and Lumbering

Threat

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- The motivations behind deforestation include direct use of the mangrove wood and leaf products and conversion of wetland habitat for coastal development projects.
- Coastal development projects include hotels, resorts, infrastructure, desalination plants, port facilities, etc.

Consequence: Habitat loss and climate vulnerability

- The delicate tidal regimes are interrupted, and the **balance between fresh and saltwater is lost**.
- It inevitably leads to altered hydrology, **erosion**, and **pollution**.
- Rivers that once travelled through the mangroves before emptying into the sea are blocked or re-routed, causing **changes in flooding, drainage**, filtration, sedimentation, temperature, and salinity.
- These changes, in turn, **affect the aquatic species**, including subsistence fish species for coastal communities.

Consequence: Loss of species and genetic diversity

- **Species diversity and genetic diversity** are among the first casualty of the destruction of mangroves.
- The trees and associated species (e.g., birds, snakes, crabs) are visibly lost, but so too are the specific genotypes and phenotypes that have evolved in microhabitats to withstand insects, tidal fluctuations, precipitation patterns and salinity regimes.

Charcoal and Lumber Industries

- Mangrove wood is used for building material, fencing, and fuel.
- It also yields valuable, high-quality charcoal.
- In places where fishing has declined, people have turned to charcoal production, which furthers the cycle of habitat loss and fishery decline.

Climate Change

- For mangroves, **sea-level rise is the biggest climate-related threat**, with some tree species unable to tolerate the influx of saltwater or escape the surging tides.
- Coastal wetlands, including mangrove forests, absorb a significant amount of greenhouse gas emissions.
- When these forests are cleared, we compound the climate change problem by releasing even more carbon into the atmosphere.

Replantation Does not Produce Optimum Results

- Mangroves are not species-rich, especially in comparison with other tropical forests.
- And in the areas where replanting is attempted, it is often done with seeds of one species rather than the mix of species that initially existed.
- This means reforestation and afforestation cannot reverse mangrove habitat loss.
- An IPCC report warns Mumbai's administrators that frequent sea-level events due to climate change, coupled with trends in coastal development, will increase annual flood damages by 2-3 times by 2100.

The Curious Case of Mumbai's Coastal Road Project

- Research indicates that **anthropogenic climate change** will inundate sections of Mumbai by 2050.

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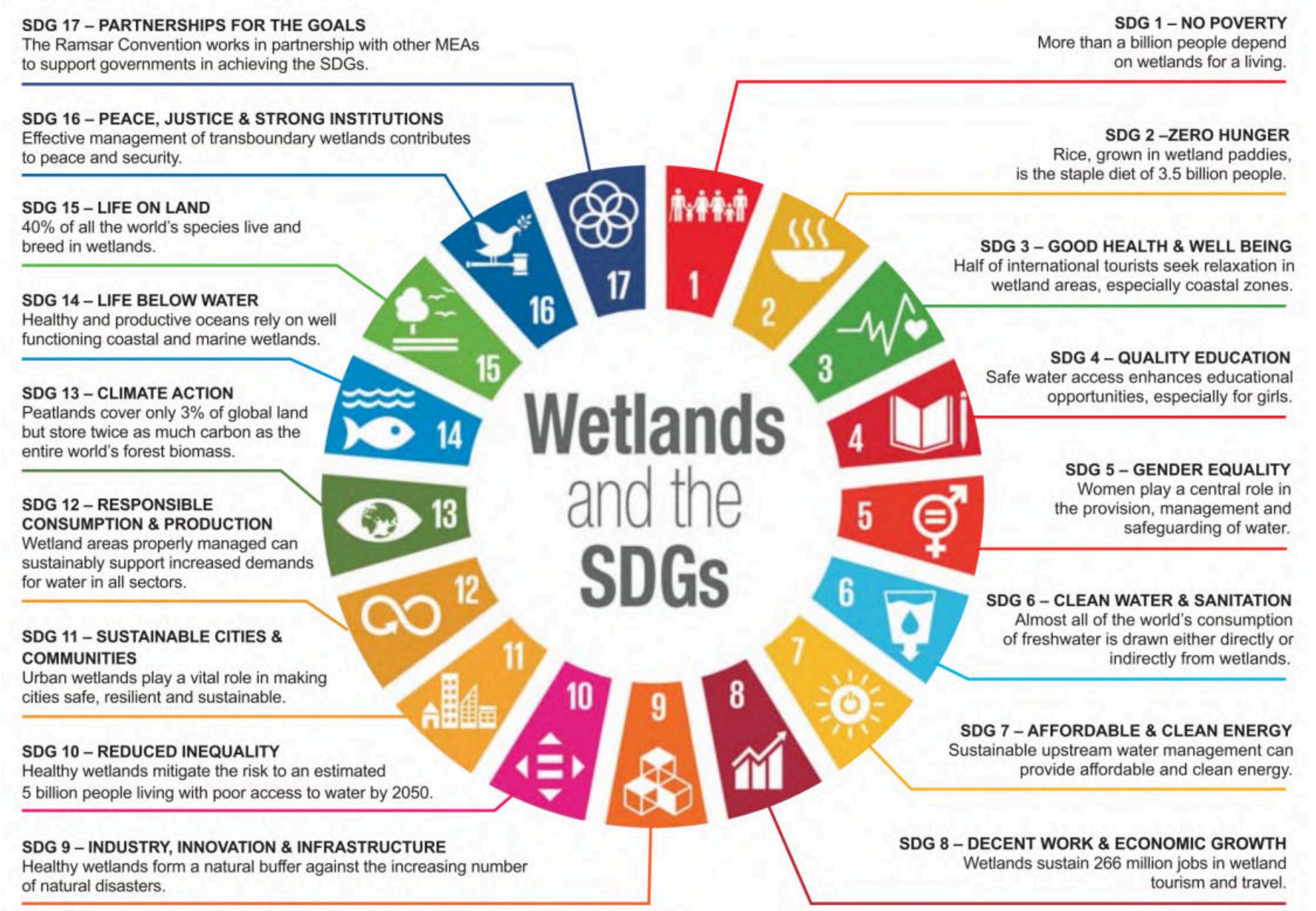
- **Mumbai, Guangzhou, Jakarta, Miami,** and **Manila** are on the list of cities endangered by climate change.
- Despite the need for action, the city is ignoring climate adaption programs. Mumbai's Coastal Road Project is an example.
- The **29.2 km long Mumbai's Coastal Road Project** (recently stalled by the Bombay High Court) is being constructed on 90 hectares of reclaimed land prone to flooding and frequent tidal inundation.
- The road will cost the public Rs 11,300 crore. But it will serve only 2% of the populace.
- The project will extend tens of meters into the sea, and 1,000 mangrove trees, which act as a natural storm/flood stopping barrier, will be cut for the project.

Ecological & Economic Damage

- It will **exacerbate the flooding situation (heavy rains + high tide)** during the South-West monsoon season.
- Change in **the tidal pattern** will lead to erosion of Mumbai's beaches.
- Tidal inundation will lead to **blockage of the city's natural drainage systems**.
- Cutting mangroves will deplete fishing grounds off the city's coast.
- While the amendment to the coastal rules mandates planting new mangroves three times the size of the destroyed mangroves, the new ones will take several years to grow.
- Also, since they will be at a different location, the **replanting will not replace the storm protection services** of the old mangroves.

8.4. Importance of Wetlands



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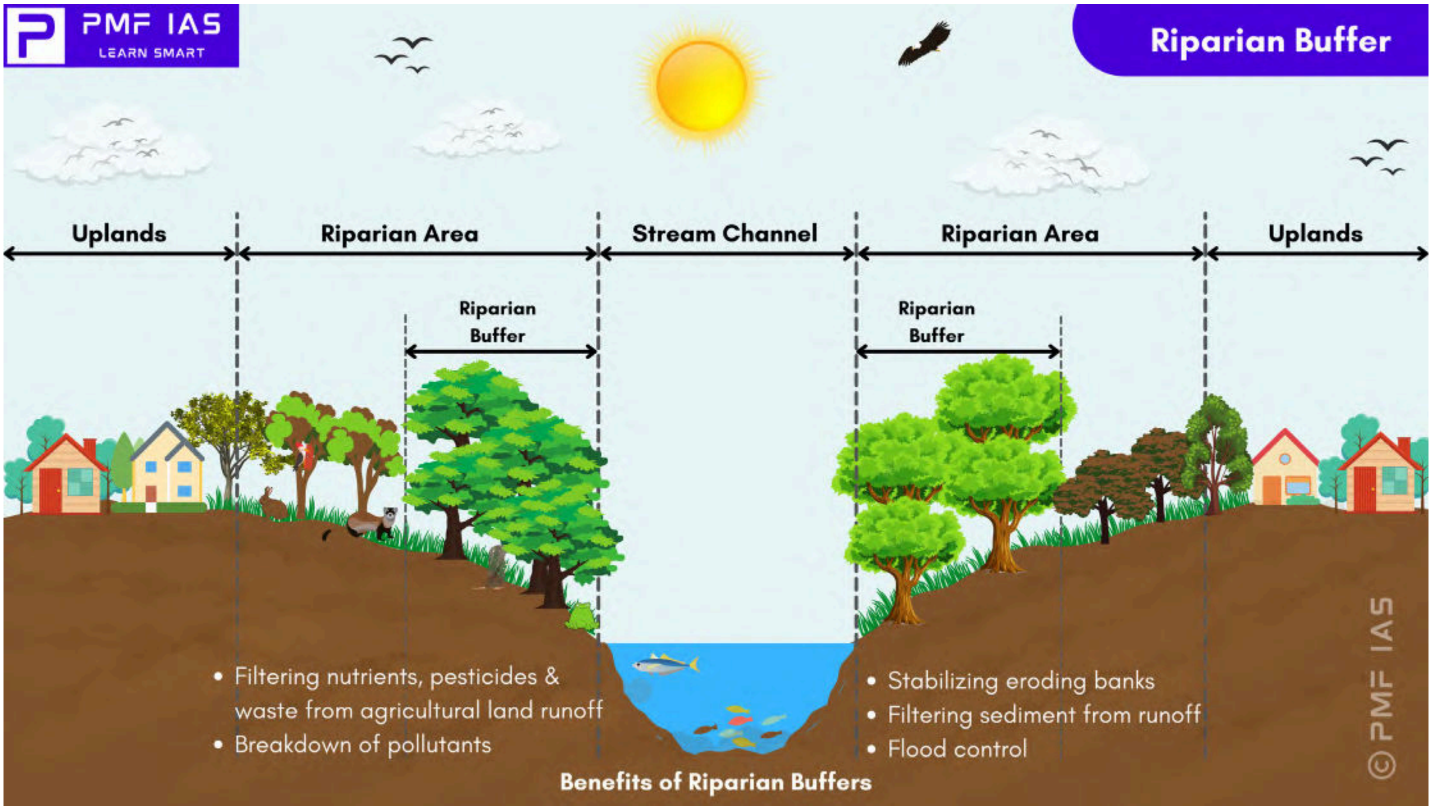
- Wetlands are indispensable for the countless benefits or "**ecosystem services**" that they provide humanity, ranging from freshwater supply, food and building materials, and biodiversity to **flood control, groundwater recharge, and climate change mitigation**.
- Wetlands are a habitat to aquatic flora and fauna, numerous species of native and **migratory birds**.
- Wetlands are an important resource for **sustainable tourism**.
- They carry out **water purification**, filtration of sediments and nutrients from surface water.
- They help in **nutrients recycling**, groundwater recharging and stabilization of local climate.



- Play an important role in flood mitigation by controlling the rate of runoff.
- Buffer (acts as a **riparian buffer**) shorelines against erosion and pollutants.
- They act as a genetic reservoir for various species of plants (especially rice).

8.5. Reasons for the Depletion of Wetlands

- **Excessive pollutants** (Industrial effluents, domestic waste, agricultural runoff etc.) are dumped into wetlands beyond the recycling capacity.
- Habitat destruction and deforestation create ecological imbalance by altering the population of wetland species.
- **Conversion of wetlands for agriculture** and encroachment by public and mafia.
- **Overfishing and fish farming (aquaculture)**.
- Overgrazing in marshy soils.
- Removal of sand from beds near seas makes the wetland vulnerable to wave action and tidal bore.

8.5.1. Mitigation of Wetland Destruction

- Demarcation of wetlands using the latest technology, proper enforcement of laws and stringent punishments for violators.
- Preventing unsustainable aquaculture and cultivation of shellfish.
- Treating industrial effluents and water from farmlands before discharging into wetlands.

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- Utilizing wetlands on a sustainable basis by giving enough time for natural regeneration.
- Artificial regeneration for a quick recovery.
- Afforestation, weed control, preventing invasive species is the key to wetland conservation.
- Preventive measures to stop the introduction of exotic **invasive species like water hyacinth**.
- Soil conservation measures & afforestation.
- Preventing grazing in peripherals of wetlands.
- Wildlife conservation, sustainable tourism, ecotourism and sensitizing local populace.
- **Eutrophication abatement by processing nutrient rich discharge into the water body**.
- Involving the local population in the conservation of wetlands.

8.6. Measures to Protect Wetlands

- **Ramsar Convention on Wetlands**
- **Ramsar Sites in India**
- **Wetlands International**
- **National Plan for Conservation of Aquatic Eco-systems (NPCA)** & **National Wetlands Conservation Programme (NWCP)**
- **Wetlands (Conservation and Management) Rules**

8.6.1. Wetlands International

- Wetlands International is a **global organization (NGO)** that works to sustain and restore wetlands and their resources for people and biodiversity.
- Wetlands International's work ranges from research, advocacy and engagement with governments, corporate and international policy fora and conventions.

Q. With reference to a conservation organization called 'Wetlands International', which of the following statements is/are correct?

1) It is an intergovernmental organization formed by the countries which are signatories to Ramsar Convention.
2) It works at the field level to develop and mobilize knowledge and use the practical experience to advocate for better policies.

Select the correct answer using the code given below.

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: Wetlands International is an NGO. b) 2 only

8.6.2. National Plan for Conservation of Aquatic Eco-systems (NPCA)

- For conservation of lakes and wetlands, the Ministry of Environment has been implementing two separate **Centrally Sponsored Schemes (CSS)**, namely
  1. the **National Wetlands Conservation Programme (NWCP)** — 115 wetlands have been identified by the MoEF, which require urgent conservation and management interventions.
  2. the **National Lake Conservation Plan (NLCP)**.

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- To promote better synergies, the NWCP & NLCP were merged to form the **National Plan for Conservation of Aquatic Eco-systems (NPCA** with the objective of conserving **both lakes and wetlands**.
- The merged scheme is operational since XII Plan Period (2012-17) with a funding pattern of **70:30 cost-sharing** between the Central Government and respective State Governments (**90:10 for the NE States**).
- The principal objectives are holistic conservation and restoration of **aquatic ecosystems (lakes & wetlands)** for achieving improvement in biodiversity and ecosystem.
- **Criteria for identification of wetlands of national importance** under NWCP (part of NPCA) **are the same** as those prescribed under the **Ramsar Convention on Wetlands**.
- The **Central Government** is responsible for the **overall coordination of wetland conservation programmes**. It provides guidelines, financial & technical assistance to the state govt.
- Since the land resources belong to states, the **State Governments/UT Administration** are responsible for the **management of wetlands**.
- **Aim of NWCP:** Conservation of wetlands to prevent their further degradation and to ensure their wise use for the benefit of local communities and overall conservation of biodiversity.
- **Objectives of NWCP:** lay down **policy guidelines** for conservation and management of wetlands, provide **financial assistance**, monitor the **implementation** and prepare an **inventory of Indian wetlands**.

8.6.3. Wetlands (Conservation and Management) Rules 2010

- **MoEF has notified rules** under the provisions of the **Environment (Protection) Act, 1986**.
- **MoEF** has notified the rules in order to ensure that there is no further degradation of wetlands.
- The rules specify activities that are harmful to wetlands, such as industrialization, construction, dumping of untreated waste and reclamation and prohibit these activities in the wetlands.
- Other activities such as harvesting and dredging may be carried out in the wetlands but only with prior permission from the concerned authorities.
- Under the Rules, wetlands have been classified for better management and easier identification.
- **Central Wetland Regulatory Authority (CWRA)** has been set up to ensure proper implementation of the Rules. The rules also encompass the **drainage area of the wetlands** as determined by the CWRA.

8.6.4. Wetlands (Conservation & Management) Rules 2017

- The new rules **replaced the 2010 version** of the rules.
- New rules have **decentralized wetlands management by giving states powers to not only identify and notify wetlands within their jurisdictions but also keep a watch on prohibited activities**.
- To oversee the work carried out by States, the rules stipulate for setting up of **National Wetlands Committee (Headed by the MoEF Secretary)** to monitor implementation of these rules.

State Wetland Authority

- **States and UTs have been given the responsibility** for wetland management by setting up State and UT Wetland Authorities (SWAs).
- It will be **headed by Environment Minister & includes** other government officials as well as experts from the fields of wetland ecology, hydrology, fisheries, landscape planning and socioeconomics.
- SWAs have to **identify and notify the wetlands for protection** within the stipulated time.
- It needs to develop a **comprehensive list of activities to be regulated and permitted** within notified wetlands and their zone of influence.
- **Recommend additional prohibited activities** for specific wetlands.

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- **SWA will define** strategies for conservation & wise use of wetlands.
- The State authorities will also need to **prepare:**
  - ✓ **A list of all wetlands** of the state or union territory **within 3 months**
  - ✓ A list of wetlands to be notified within 6 months
  - ✓ A comprehensive digital inventory of all wetlands within 1 year which will be updated every 10 years.

What cannot be notified under the Rules?

- The guidelines clarified that all wetlands, irrespective of their location, size, ownership, biodiversity, or ecosystem services values, **can be notified under the Wetlands Rules 2017** **except:**
  - ✓ River channels
  - ✓ **Paddy fields**
  - ✓ Human-made water bodies specifically constructed for drinking water
  - ✓ **Aquaculture**
  - ✓ **Salt production**
  - ✓ **Recreation**
  - ✓ **Irrigation purposes**
  - ✓ Wetlands falling within areas covered under the Indian **Forest Act, 1927, Forest (Conservation) Act, 1980, Wildlife (Protection) Act, 1972** and the **Coastal Regulation Zone Notification, 2011**.
  - ✓ Protected Areas and areas falling within the purview of Coastal Zone Regulation

Prohibited Activities under the New Rules

- Conversion of wetland for non-wetland uses.
- Setting up of any industry and expansion of existing industries,
- Manufacture/handling/storage/disposal of hazardous substances and construction and demolition waste.
- Solid waste dumping.
- Discharge of untreated wastes and effluents from industries, cities, towns, villages and other settlements.
- The Rules also restrict any kind of encroachment, poaching, or permanent construction, **except for boat jetties**.

Concerns

- **A provision in the new rules** that states, "Central government may consider proposals from the state government or union territory administration for **omitting any of the (prohibited) activities on the recommendation of the authority**" **can be misused.**
- According to the 2010 rules, anyone aggrieved with the CWRA's decisions could have filed an appeal with the National Green Tribunal, but the **new 2017 rules are silent on the appeal process**.
- Subjective definition of **"wise use"** which is to be determined by state wetland authority.

8.6.5. Ramsar Convention on Wetlands

- The Ramsar Convention on Wetlands is an **international treaty** for "**the conservation and sustainable use of wetlands**".
- It is also known as the **Convention on Wetlands**.
- It is named after the city of **Ramsar in Iran**.
- The convention was signed on the 2nd of February 1971.
- The **2nd of February** each year is **World Wetlands Day**.
- The number of parties to the convention (COP) is171 (as of May 2021).
- At the centre of the Ramsar philosophy is the "**wise use**" of wetlands.

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- **Wise use: maintenance of ecological character** within the context of **sustainable development**.
- Need for Such Convention: **64% of the world's wetlands have disappeared** in the last century.

Definition of Wetland by Ramsar Convention

- Ramsar Convention on Wetlands define wetlands as
  - ✓ areas of marsh, fen, peatland or water,
  - ✓ whether **natural or artificial**,
  - ✓ **permanent or temporary**,
  - ✓ with water that is static or flowing, fresh, brackish or salt,
  - ✓ including areas of marine water the **depth of which at low tide does not exceed six metres**".
- Hence wetlands include **all lakes and rivers**, **underground aquifers**, swamps and marshes, **wet grasslands**, peat-land, **oases**, estuaries, deltas and **tidal flats**, **mangroves** and other coastal areas, coral reefs, and all human-made sites such as fishponds, **rice paddies**, **reservoirs** and **salt pans**.

Criteria for Identification of Wetlands under Ramsar Convention

1. **Unique wetland:** contains a **rare** or **unique** example of a **natural or near-natural** wetland type.
2. **Endangered species:** supports threatened, vulnerable, endangered, or critically endangered species/ecological communities.
3. **Essential species:** supports populations of plant and/or animal species important for maintaining biological diversity.
4. **Species protection:** supports plant and/or animal species at a critical stage in their life cycles or provides refuge during adverse conditions.
5. **Waterbirds:** regularly supports 20,000 or more water birds.
6. **Single species of water birds:** regularly supports 1% of the individuals in a population of one species or subspecies of water birds.
7. **Indigenous fish:** supports a significant proportion of indigenous fish subspecies.
8. **Multirole:** is an important source of food for fishes, spawning ground, nursery and/or migration path.
9. **Ecotourism:** is an important source of food and water resource, increased possibilities for recreation and ecotourism, etc.

Contracting Parties (COP) to Ramsar Convention on Wetlands

- COP is the policy-making organ of the convention, which adopts decisions (resolutions and recommendations) to administer the work of the convention.

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- Every **three years**, representatives of the COP meet as the Conference of the Contracting Parties (COP)
- **COP13 took place in Dubai, United Arab Emirates, in 2018**.
- The **Chinese city of Wuhan** — situated on the **left bank of the Yangtze River (the longest river in Asia – 6,300 km)** — was to host the **COP14 in 2021** (uncertain due to the ongoing pandemic).

The Responsibilities of the Contracting Parties

- A key commitment of the Contracting Parties is to **identify and place suitable wetlands** onto the **List of Wetlands of International Importance**, also known as the **Ramsar List**.
- Contracting Parties are **expected (not mandated)** to manage their Ramsar Sites so as to maintain their ecological character and retain their essential functions and values for future generations.
- The convention specifies that "Contracting Parties **shall (not may)** formulate and implement their planning so as to promote the conservation of the wetlands included in the List".

Q. Consider the following statements:

1. Under Ramsar convention, it is mandatory on the part of the Government on India in protect and conserve all the wetlands in the territory of India
2. The Wetlands (Conservation and Management) Rules, 2010 were framed by the Government of India based on the recommendations of Ramsar convention.
3. The Wetlands (Conservation and Management) Rules, 2010 also encompass the drainage area or catchment regions of the wetlands as determined by the authority

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Explanation:

- Contracting Parties are **expected (not mandated)** to manage their **Ramsar Sites** so as to maintain their ecological character and retain their essential functions and values for future generations.
  - ✓ It is expected (not mandated) for the government to protect the wetland included in the list.
- The convention specifies that "Contracting Parties **shall (not may)** formulate and implement their planning so as to promote the conservation of the wetlands included in the List".
  - ✓ It is expected (not mandated) for the government to protect the wetland included in the list, **not all**.
  - ✓ Ramsar Convention **recommends** making laws to protect such wetlands.

Answer: b) 2 and 3 only; but as per the UPSC official key, the answer is c) 3 only

International Organization Partners of Ramsar Convention

- The Ramsar Convention works closely with six organizations known as International Organization Partners (IOPs). These are:
  1. **Birdlife International**
  2. **International Union for Conservation of Nature (IUCN)**
  3. **International Water Management Institute (IWMI)**
  4. **Wetlands International**
  5. **World Wide Fund for Nature (WWF)**

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6. International Wildfowl & Wetlands Trust (WWT)

Other Partners

- Convention on Biological Diversity (CBD)
- Convention to Combat Desertification (UNCCD),
- Convention on the Conservation of Migratory Species of Wild Animals
- Convention on Migratory Species (CMS),
- World Heritage Convention (WHC) and
- Convention on International Trade in Endangered Species (CITES).
- Project funding is done by various groups like multilateral development banks, bilateral donors, **UN agencies such as UNEP, UNDP**, Non-governmental organizations etc.

8.6.6. Ramsar Site

- When a country accedes to the convention, **it must designate at least one wetland** as a **Wetland of International Importanc**e.
- The inclusion of a "Ramsar Site" in the list embodies the **government's commitment** to take the steps necessary to ensure that its ecological character is maintained.
- Today, the Ramsar List is the world's largest network of protected areas.
- There are over 2,400 Ramsar Sites covering 2.5 million sq km on the territories of **171 Ramsar Contracting Parties** across the world.

- The world's first site was the **Cobourg Peninsula in Australia**, designated in 1974.
- The countries with the most Ramsar Sites are the United Kingdom with 175 and Mexico with **142**.
- Bolivia has the largest area under Ramsar protection.
- As of May 2021, there are **42 Ramsar Sites in India**.

Deletion from the List

- A Contracting Party may, because of its **urgent national interest**, **delete or restrict** the boundaries of wetlands already included in the list.
- However, such deletions or restrictions **should be compensated** for by the creation of additional nature reserves either in the same area or elsewhere.
- **No Ramsar Site has ever been "deleted" in this way**, and Parties have only extremely rarely restricted the boundaries of a Site on this basis (success of Ramsar Convention).

Transboundary Ramsar Sites

- Many important wetlands extend as one ecologically coherent whole across national borders.

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- In these cases, COP can agree to establish Ramsar Sites on their territory as parts of a bigger **Transboundary Ramsar Site**.
- The authorities on both sides of the border agree to collaborate in the management of the site.

The Montreux Record

- Ramsar Sites which are **potentially at risk** as a result of technological developments, pollution or other human interference may be placed on the **Montreux Record**.
- The Montreux Record of Ramsar Sites includes sites where **changes in ecological character have occurred, are occurring, or are likely to occur**."

Q. If a wetland of international importance is brought under the 'Montreux Record', what does it imply?

a) Changes in ecological character have occurred, are occurring or are likely to occur in the wetland as a result of human interference.
b) The country in which the wetland is located should enact a law to prohibit any human activity within five kilometres from the edge of the wetland
c) The survival of the wetland depends on the cultural practices and traditions of certain communities living in its vicinity, and therefore the cultural diversity therein should not be destroyed
d) It is given the status of 'World Heritage Site'

Answer: a)

8.6.7. Ramsar Sites of India

State/UT	No. of Ramsar Sites	State/UT	No. of Ramsar Sites
Uttar Pradesh	**8**	Andhra Pradesh	1
Punjab	**6**	Bihar	1
Himachal Pradesh	**3**	Assam	1
Kerala	**3**	Bihar	1
Union Territory of J&K	**3**	Gujarat	1
Odisha	2	Madhya Pradesh	1
Rajasthan	2	Manipur	1
West Bengal	2	Tamil Nadu	1
Maharashtra	2	Tripura	1
Union Territory of Ladakh	2	Uttarakhand	1
			42

	Ramsar Site	State	Area (km^2)	Description
1	**Ashtamudi Wetland**	Kerala	614	• It is a natural backwater in Kollam district. • River Kallada and Pallichal drains into it. • It forms an estuary with Sea at **Neendakara** (famous fishing harbour in Kerala). • **National Waterway 3** passes through it.
2	**Beas Conservation Reserve**	Punjab	64	• It is a 185-kilometre stretch of the Beas River. • The stretch is dotted with islands, sand bars and **braided channels**. • The Reserve hosts the only known population in India of the en-

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				dangered **Indus River dolphin (EN)**. • In 2017, a programme was initiated to re-introduce the **critically endangered gharial**.
3	**Bhitarkanika Mangroves**	Odisha	650	• It is part of the **Bhitarkanika Wildlife Sanctuary**. • The core area of the sanctuary was declared Bhitarkanika National Park. • **Gahirmatha Marine Wildlife** Sanctuary is adjacent to the Bhitarkanika Wildlife Sanctuary. • It is famous for: ✓ **Olive ridley turtle (VU)** ✓ **Saltwater crocodile (LC)** • The core area of Bhitarkanika Wildlife Sanctuary was declared **Bhitarkanika National Park**. • Bhitarkanika Wildlife Sanctuary includes **Gahirmatha Marine Wildlife Sanctuary**.
4	**Bhoj Wetland**	Madhya Pradesh	32	• The wetland consists of two lakes located in the city of **Bhopal**. • The two lakes are the Bhojtal and the Lower Lake. • It is a **human-made reservoir**. • The largest bird of India, the **sarus crane (VU)** is found here.
5	**Chandra Taal**	Himachal Pradesh	.49	• It is a high-altitude lake. • It supports IUCN Red listed **Snow Leopard (VU)**.
6	**Chilika Lake**	Odisha	1165	• It is a brackish water lagoon at the mouth of the Daya River. • It is the **largest coastal lagoon** in India. • Birds from as far as the Caspian Sea, Lake Baikal, Aral Sea and other remote parts of Central Asia, Ladakh and Himalayas come here. • In 1981, Chilika Lake was designated the **first Indian wetland of international importance under the Ramsar Convention**. • **Nalbana Bird Sanctuary** is the core area of the Ramsar designated wetlands of Chilika Lake. • The **Irrawaddy dolphin (EN)** is the **flagship species of Chilika lake**. • Chilka is home to the only known population of Irrawaddy dolphins in India.
7	**Deepor Beel**	Assam	40	• A permanent freshwater lake in a **former channel of the Brahmaputra River**. • It is a few kilometres to the left of **Guwahati,** whereas **Pobitora Wildlife Sanctuary** is around 35 km to the right.
8	**East Kolkata Wetlands**	West Bengal	125	• It is a multiple use wetland that serves the city of Kolkata.
9	**Harike Wetland**	Punjab	41	• It is a shallow water reservoir at the **confluence of the Beas and Sutlej rivers**.
10	**Hokera Wetland**	Union Territory of J&K	13.75	• It is only 10 km from **Srinagar**. • It is a natural perennial wetland contiguous to the **Jhelum basin**.
11	**Kanjli Wetland**	Punjab	1.83	• The stream is considered to be the most significant in the state from the religious point of view, as it is associated with the first guru of the Sikhs, Shri Guru Nanak.
12	**Keoladeo National**	Rajasthan	28.73	• A complex of ten artificial, seasonal lagoons, varying in size.

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	Park			• Vegetation is a mosaic of scrub and open grassland that provides a habitat for breeding, wintering and staging migratory birds. • The invasive growth of the grass **Paspalum distichum** has changed the ecological character of large areas of the site, reducing its suitability for certain waterbird species, notably the **Siberian crane (CR)**.
13	**Keshopur-Miani Community Reserve**	Punjab	34	• The site is an example of wise use of a community-managed wetland, which provides food for people and supports local biodiversity.
14	**Kolleru Lake**	Andhra Pradesh	901	• A natural **eutrophic lake** situated between the river basins of the **Godavari** and the **Krishna**. • It was previously a lagoon, but now it is several kilometres inland due to the coastline of emergence and delta formation.
15	**Loktak Lake**	Manipur	266	• Loktak Lake is the **largest freshwater lake** in the north-eastern region of the country. • **Keibul Lamjao,** the **only floating national park** in the world, floats over it.
16	**Nalsarovar Bird Sanctuary**	Gujarat	123	• A natural freshwater lake (a relict sea) is the **largest natural wetland in** Gujarat. • The wetland is a lifeline for a satellite population of the endangered **Indian Wild Ass (NT)**.
17	**Nandur Madhameshwar**	Maharashtra	14	• Construction of the Nandur Madhameshwar Weir at the confluence of the Godavari and Kadwa Rivers helped create a thriving wetland.
18	**Nangal Wildlife Sanctuary**	Punjab	1	• Located in the Shiwalik foothills of Punjab. • It supports abundant flora and fauna, including threatened species, such as the endangered **Indian pangolin** and Egyptian vulture. • It occupies a human-made reservoir constructed as part of the **Bhakra-Nangal** Project in 1961. • The site is of historical importance as the Indian and Chinese Prime Ministers formalized the "**Five Principles of Peaceful Coexistence**" there in 1954.
19	**Nawabganj Bird Sanctuary**	UP	2	• It was renamed **Chandra Shekhar Azad Bird Sanctuary** in 2015.
20	**Parvati Arga Bird Sanctuary**	UP	7	• It is a permanent freshwater environment consisting of two **oxbow lakes**. • The sanctuary is a refuge for some of India's threatened vulture species: the critically endangered white-rumped vulture and Indian vulture.
21	**Point Calimere Wildlife & Bird Sanctuary**	Tamil Nadu	385	• One of the last remnants of **Dry Evergreen Forests**. • Habitat: Dry Evergreen Forests, Mangrove & Wetlands.
22	**Pong Dam Lake**	Himachal Pradesh	156.62	• It is also known as **Maharana Pratap Sagar**.
23	**Renuka Lake**	Himachal Pradesh	.2	• A natural wetland with freshwater springs and inland subterranean karst formations.
24	**Ropar Wetland**	Punjab	13.65	• A **human-made wetland** of lake and river formed by the construction of a barrage for diversion of water from the **Sutlej River**.
25	**Rudrasagar Lake**	Tripura	2.4	• It is a reservoir fed by three perennial streams discharging to the

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				River Gomti. • It is an ideal habitat for IUCN Red listed **Three-striped Roof Turtle (CR)**.
26	**Saman Bird Sanctuary**	UP	5	• It is a **seasonal oxbow lake** on the Ganges floodplain.
27	**Samaspur Bird Sanctuary**	UP	8	• It is a perennial lowland marsh typical of the Indo-Gangetic Plains. • The Sanctuary harbours threatened species such as the endangered Egyptian vulture.
28	**Sambhar Lake**	Rajasthan	240	• The Sambhar Salt Lake is **India's largest inland saltwater lake**. • It is a key wintering area for tens of thousands of **flamingos**.
29	**Sandi Bird Sanctuary**	UP	3	• The wetland is typical of the Indo-Gangetic plains.
30	**Sarsai Nawar Jheel**	UP	2	• It is a permanent marsh. • It is an example of co-habitation of humans and wildlife. • The site's name is derived from the large non-migratory **sarus crane (VU)**.
31	**Sasthamkotta Lake**	Kerala	3.73	• It is the largest freshwater lake in Kerala, situated in the Kollam district. • **River Kallada** had a unique replenishing system through a **bar of paddy fields**. • The lake is now depleting due to the destruction of the replenishing mechanism.
32	**Sundarban Wetland**	West Bengal	4230	• Sundarbans Wetland is located within the largest mangrove forest in the world. • It is the **largest Ramsar Site in India**. • The Indian Sundarbans, covering the south-westernmost part of the delta, constitutes over 60% of the country's total mangrove forest area and includes 90% of Indian mangrove species.
33	**Surinsar-Mansar Lakes**	UT of J&K	3.5	• Freshwater composite lake in semi-arid Panjab Plains, adjoining the **Jhelum Basin**.
34	**Tsomoriri**	UT of Ladakh	120	• A freshwater to brackish lake lying at 4,595m above sea level. • The site is said to represent the only breeding ground outside of China for one of the most endangered cranes, the **Black-necked Cranes (NT)** and the only breeding ground for **Bar-headed geese** in India. • The Great Tibetan Sheep or Argali and Tibetan Wild Ass are endemic to the region. • With no outflow, evaporation in the arid steppe conditions causes varying levels of salinity.
35	**Upper Ganga River (Brijghat to Narora Stretch)**	UP	265.9	• The river provides habitat for IUCN Red listed **Ganges river dolphin (EN)** and critically endangered gharial.
36	**Vembanad-Kol Wetland**	Kerala	1512.5	• Largest lake of Kerala, spanning across Alappuzha, Kottayam, and Ernakulam districts. • It is the **second-largest Ramsar Site in India after Sundarbans**. • **It is also the longest lake in India**. • It is below sea level and is famous for exotic fish varieties and Paddy fields that are below sea level.

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37	**Wular Lake**	UT of J&K	189	• It is the **largest freshwater lake in India**.
38	**Asan Barrage**	Uttarakhand	4.44	• It is a stretch of the **Asan River** running down to its confluence with the **Yamuna River** in the Dehradun district. • The stretch supports many species of birds, including the **critically endangered red-headed vulture (Indian black vulture), white-rumped vulture** and **Baer's pochard (CR)**.
39	**Kanwar Taal or Kabar Taal Lake**	Bihar, Begusarai	26.2	• It lies in the Indo-Gangetic Plain. • The wetland is an important stopover for the Central Asian Flyway migratory waterbirds. • Five critically endangered species inhabit the site, including **three vultures – the red-headed vulture, white-rumped vulture** and **Indian vulture** – and two waterbirds, the **Baer's pochard (CR)** and **sociable lapwing (CR)**.
40	**Sur Sarovar**	UP, Agra district	4.31	• It was created to supply water to the city of **Agra**. • The wetland is an important stopover for the Central Asian Flyway migratory waterbirds.
41	**Lonar Lake**	Maharash-tra, Buldhana district	4.27	• It is an **endorheic (closed basin) crater lake** formed by a **meteor-ite impact**. • It is high in salinity and alkalinity due to the lack of an outflow. • Recently, the colour of Lonar lake water had turned pink due to a large presence of the salt-loving "**haloarchaea**" microbes. • **Haloarchaea or halophilic archaea** is a bacteria culture that pro-duces pink pigment and is found in water saturated with salt.
42	**Tso Kar**	Ladakh, Leh district	95.77	• **Tso Kar wetland is India's 42nd Ramsar site & the second in the UT of Ladakh.** • **The Tso Kar Basin is a high-altitude wetland complex consist-ing of two principal waterbodies:** 1. **Startsapuk Tso, a freshwater lake to the south, &** 2. **Tso Kar** itself, a **hypersaline lake** to the north. • It is called Tso Kar, meaning white lake, because of the **white salt efflorescence** found on the margins due to the evaporation of highly saline water. • Tso Kar Basin is an **Important Bird Area** according to BirdLife In-

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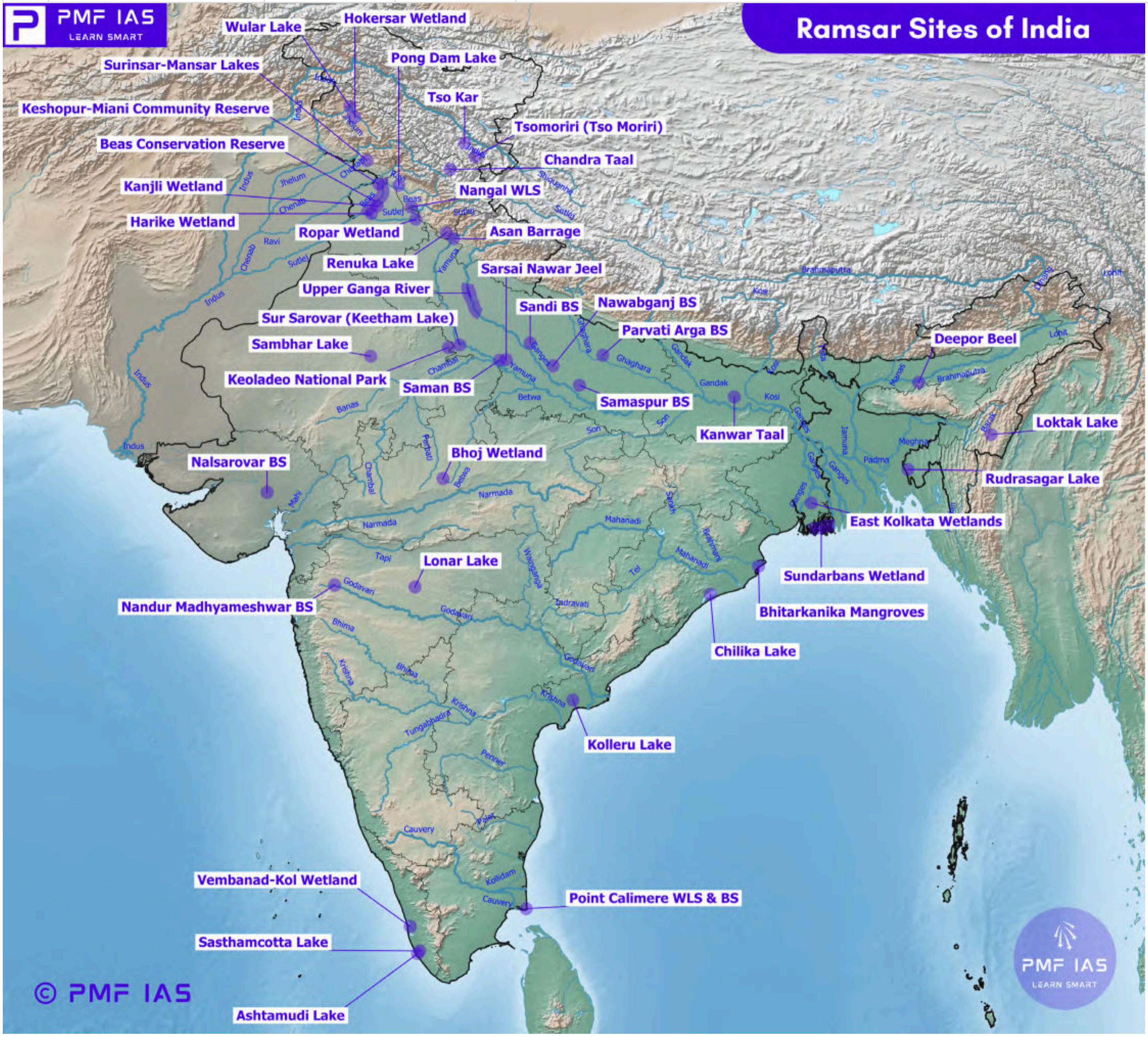
				ternational. • It is a key staging site in the Central Asian Flyway. • Also, the site is the most important breeding area of the **Black-necked Cranes (NT)** in India.



8.6.8. Largest and Smallest and Oldest Ramsar Sites of India

Largest Ramsar Sites of India		
Ramsar Site	**State**	**Area in Sq. km**
1) Sunderbans Wetland	**West Bengal**	**4230**
2) Vembanad Kol Wetland	**Kerala**	**1512**
3) Chilka Lake	**Orissa**	**1165**
4) Kolleru Lake	Andhra Pradesh	901
5) Bhitarkanika Mangroves	Orissa	650

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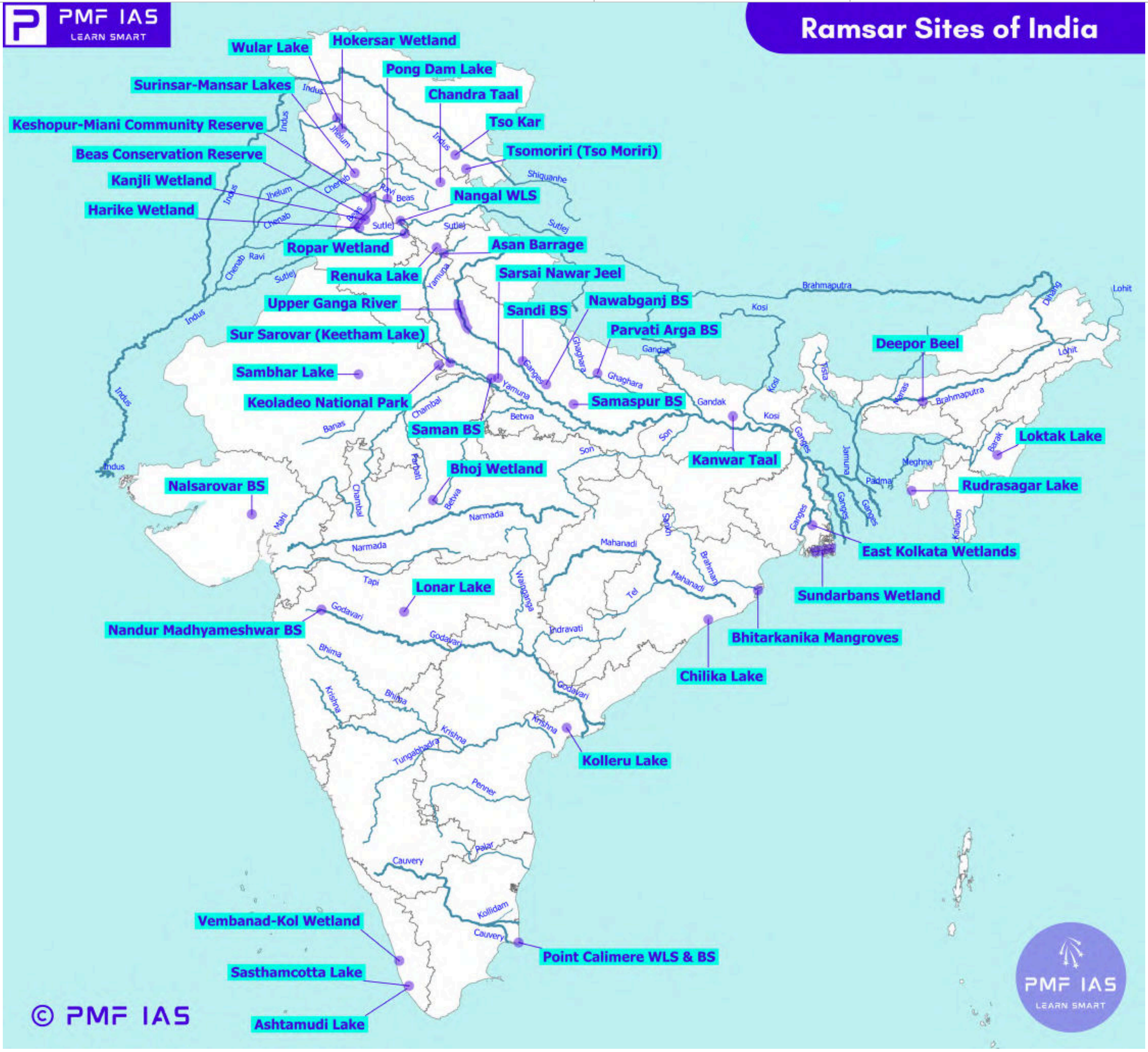
6) Asthamudi Wetland	Kerala	614
Smallest Ramsar Site of India		
Renuka Wetland	**Himachal Pradesh**	**0.2**
Oldest Ramsar Sites of India		
1) Chilka Lake	**Orissa**	**1981**
2) Keoladeo Ghana NP	**Rajasthan**	**1981**



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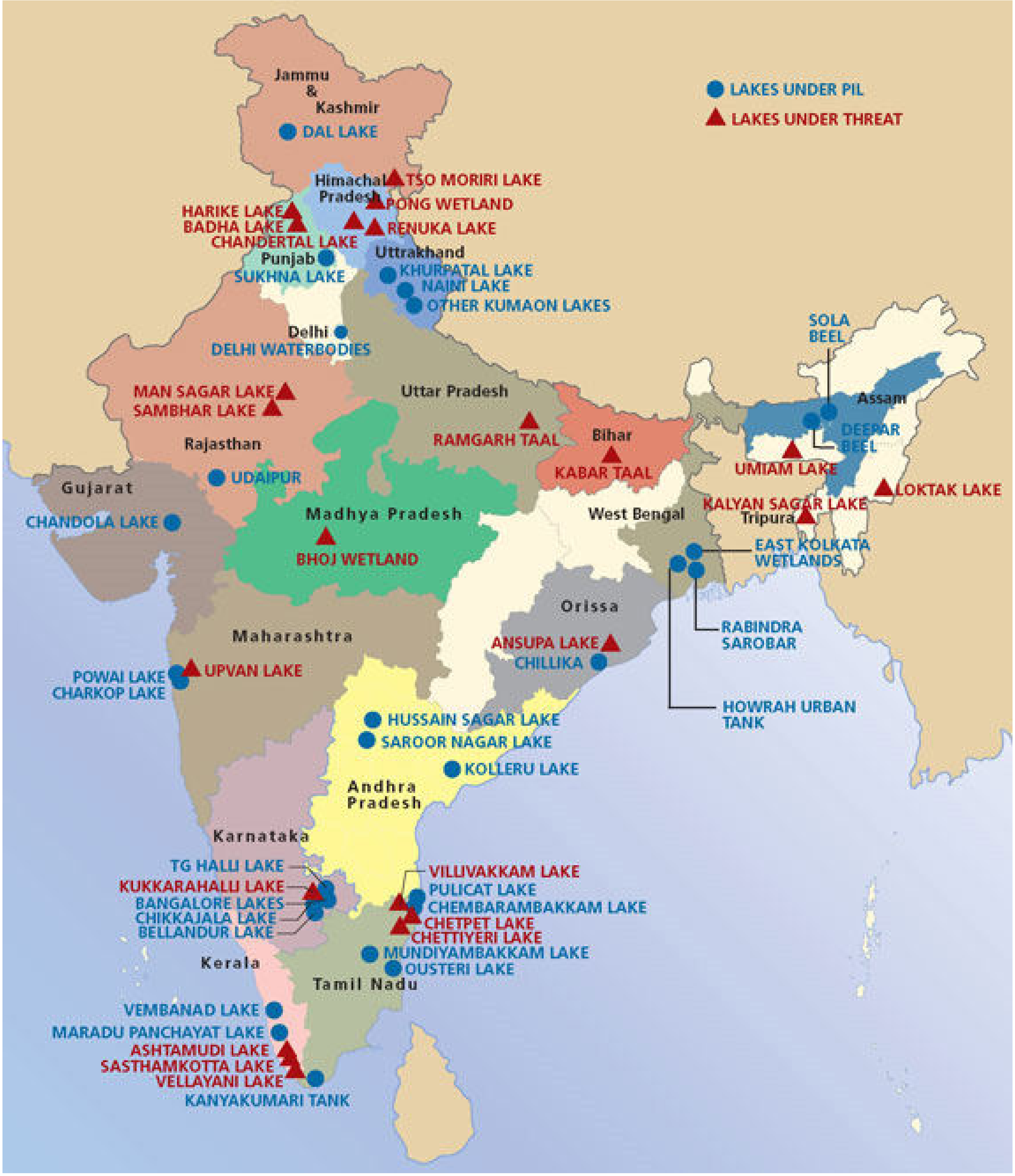

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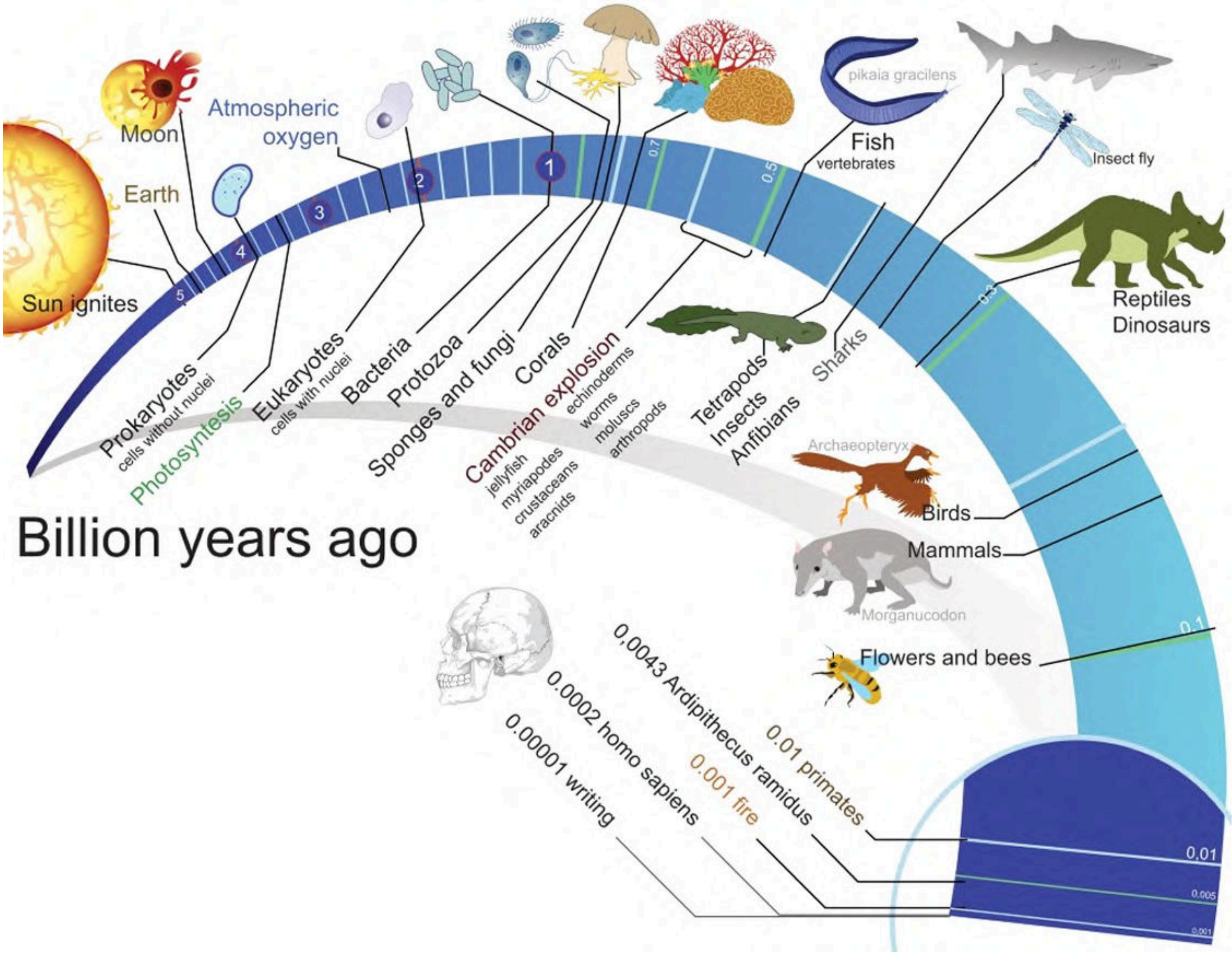
9. Evolution of the Biosphere



- The **geological time scale (GTS)** divides and chronicles earth's evolutionary history into various periods based on definite events that marked a major change in earth's physical, chemical, and biological features.
- The primarily defined divisions of time are **eons**, the **Hadean**, the **Archean**, the **Proterozoic** and the **Phanerozoic**. The first three of these can be referred to collectively as the **Precambrian supereon**.
- Each **eon** is subsequently divided into **eras**, which in turn are divided into periods, which are further divided into **epochs**.

SuperEon ➔ Eon ➔ Era ➔ Period ➔ Epoch

9.1. Hadean Eon

- The Hadean eon (4,540 – 4,000 mya) represents the **time before a reliable (fossil) record of life**.
- Temperatures are extremely hot, and much of the earth was molten.
- **Volcanic outgassing** probably created the **primordial atmosphere** and then the ocean.
- The early atmosphere contained almost **no oxygen**.

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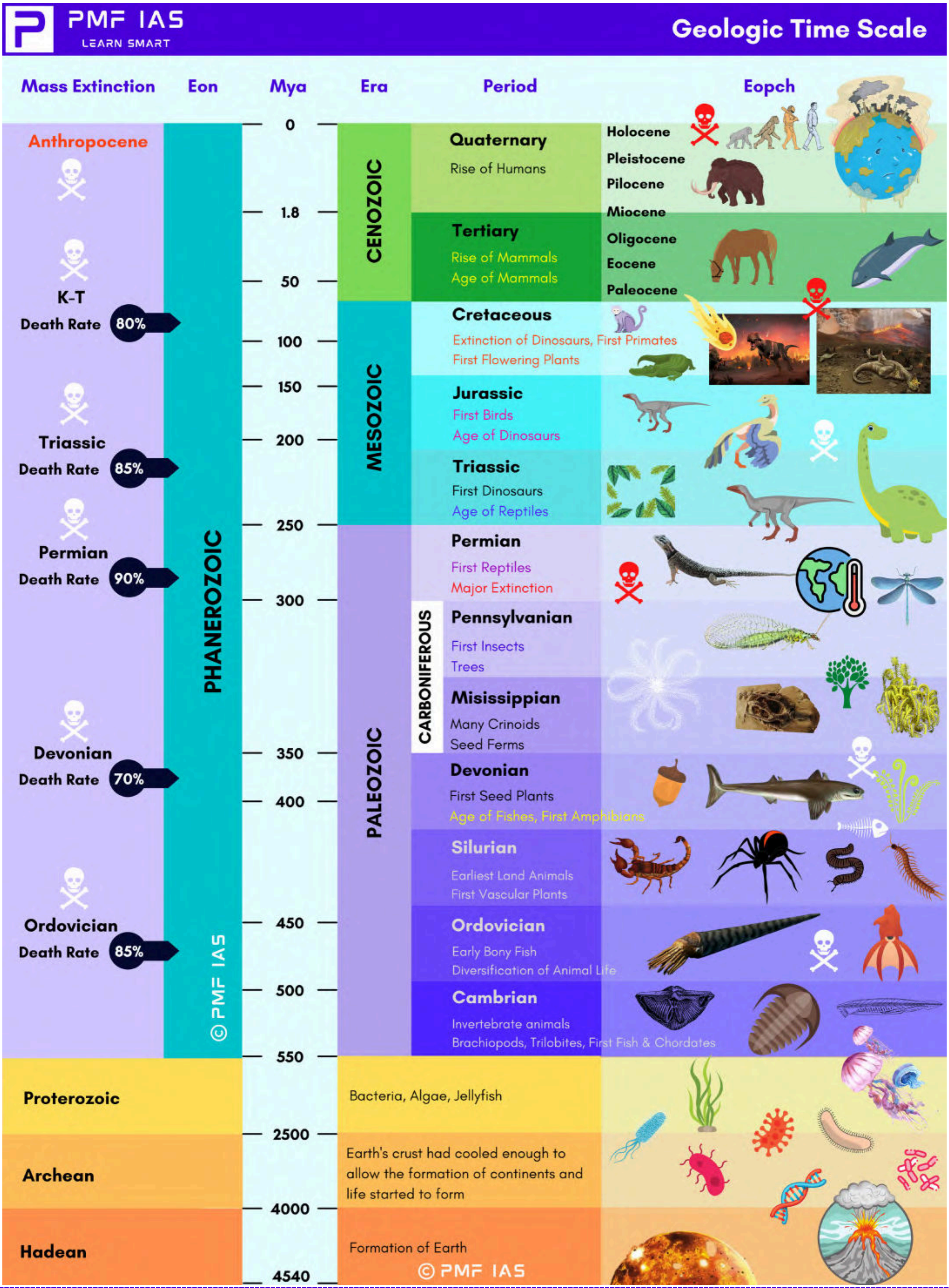

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- Over time, the earth cooled, causing the formation of a **solid crust**, leaving behind hot volatiles which probably resulted in a **heavy CO_2 atmosphere** with **hydrogen** and **water vapour**.
- Liquid water oceans existed despite the **surface temperature of 230° C** because, at an atmospheric pressure of above **27 atmospheres**, caused by the **heavy CO_2 atmosphere**, water is still liquid.

Is it possible to boil water (change the state of water from liquid to gas) at room temperature?

- Yes, it is possible by decreasing the ambient pressure.Because the **boiling point of liquids can be reduced by reducing the ambient pressure and vice versa**.
- As ambient pressure decreases, molecules evaporating from a boiling liquid meet less resistance from air molecules and enter the air more easily.
- Hence, it is possible to convert water to steam at room temperature and keep water in the liquid state even when the temperature is above 100° C, just by altering the ambient pressure.

- **As the cooling continued, dissolving in ocean water removed most CO_2 from the atmosphere (if global cooling removed carbon dioxide from the atmosphere, what will global warming do?)**.
- Hydrogen and helium are expected to escape due to atmospheric escape continually.

9.2. Archean Eon

- The **beginning of life** on earth and evidence of **cyanobacteria** date to 3500 mya.
- Life was limited to simple single-celled organisms lacking nuclei, called **Prokaryotes**.
- The atmosphere was **without oxygen,** and the atmospheric pressure was around **10 to 100 atmospheres**.
- The earth's crust had cooled enough to allow the **formation of continents**.
- Volcanic activity was considerably higher than today, with numerous lava eruptions.
- The oceans were **more acidic due to dissolved carbon dioxide** than during the Proterozoic.
- By the end of the Archaean, liquid water was prevalent, and deep oceanic basins are known to have existed.
- The **earliest identifiable fossils** consist of **stromatolites**, which are microbial mats formed in shallow water by **cyanobacteria**.

9.3. Proterozoic Eon

- It is the last eon of the Precambrian "supereon".

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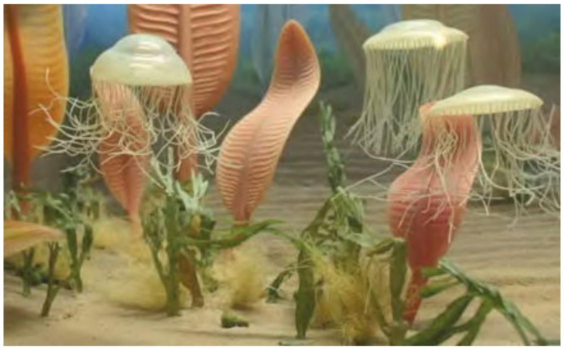
- It spans from the time of **appearance of oxygen** in the earth's atmosphere to **just before the proliferation of complex life (such as corals)** on the earth.
- **Bacteria** begin producing **oxygen**, leading to the sudden rise of life forms.
- **Eukaryotes** (have a nucleus) emerge, including some forms of soft-bodied **multicellular** organisms.



- Earlier forms of fungi formed around this time.
- The early and late phases of this eon may have undergone **Snowball Earth** periods (the planet suffered **below-zero temperatures, extensive glaciation (global cooling),** and, as a result, **drop in sea levels**).

Snowball Earth: *The Snowball Earth hypothesis proposes that the earth's surface became entirely or nearly entirely frozen at least once (**when most of the earth's landmass was near the south pole**), sometime earlier than 650 Mya (million years ago).*

9.3.1. Events that Can Cause Global Cooling

Natural Events that Can Cause Global Cooling

- **Large Meteor Impacts (asteroid impact)** and **Supervolcanoes** spew out (**volcanic outgassing**) so much **sulfur dioxide** into the atmosphere that the sulfur dioxide moves into the **stratosphere** and combines with water to form **sulfuric acid aerosols (highly reflective/high albedo)** that **reflect incoming solar radiation**, causing **cooling of the earth's surface (volcanic winter)**.
- The ash, dust & soot cloud plumes further reduce the sunlight reaching the earth and cause more cooling.

Anthropogenic Events That Can Cause Global Cooling

- **Nuclear winter** is a severe and prolonged global climatic cooling effect that could occur following the event of **nuclear holocaust** (mass detonation of nuclear weapons).
- It is hypothesized that a nuclear apocalypse can release an immeasurable amount of dust, ash and soot into the atmosphere, which can **block sunlight from reaching the surface and cause global cooling**.
- It can also cause **widespread ozone depletion** as **nuclear detonations break down the air around them (similar to lightning)** and produce **large amounts of nitrogen oxides (NO_x)**.
- Thermal conventions and massive smoke plumes transport the **nitrogen oxides** to the **stratosphere,** where they **catalytically break down the ozone layer (stratospheric ozone or good ozone)**.

9.4. Phanerozoic Eon

- The boundary between the Proterozoic and the Phanerozoic eons was set when the **first fossils of animals appeared**.
- Life remained mostly small and microscopic until about 580 million years ago, when complex multicellular life arose, developed over time, and culminated in the **Cambrian Explosion** about **541 million years ago**.
- This sudden diversification of life forms produced most of the major life forms known today.

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- **Plantlife on land** appeared in the early Phanerozoic eon.
- **Complex life**, including vertebrates, begin to dominate the earth's ocean.
- Gradually, life expands to land and all familiar forms of plants, insects, animals, and fungi begin appearing.
- **Birds, the descendants of dinosaurs**, and, more recently, **mammals** emerge.
- **Modern animals—including humans**—evolve at the most recent phases of this eon (**2 million years ago**).

The Phanerozoic eon is divided into three eras:

1. **the Palaeozoic**, an era of **arthropods, amphibians, fishes, and the first life on land**;
2. **the Mesozoic**, which spanned the rise, **reign of reptiles, climactic extinction of the non-avian dinosaurs**, the evolution of mammals and birds; and
3. **the Cenozoic**, which saw the **rise of mammals**.

- The Phanerozoic is divided into three eras: the Paleozoic, Mesozoic, and Cenozoic, which are further subdivided into 12 periods.

9.4.2. Paleozoic Era

- There are six periods in the Paleozoic era: Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian.

Cambrian Period

- Spans from 541 to 485 million years ago.
- The Cambrian sparked a **rapid expansion in evolution** in an event known as the **Cambrian Explosion** during which the greatest number of creatures evolved in a single period in the history of the earth.
- Plants like **algae** evolved, and **arthropods dominated the fauna**.
- Almost all marine phyla evolved in this period.

Ordovician Period

- Spans from 485 million years to 440 million years ago.
- Many species still prevalent today evolved, such as **primitive fish, corals,** etc.
- The most common forms of life, however, were **trilobites, snails and shellfish**.
- More importantly, the first arthropods crept ashore **(the beginning of terrestrial lifeforms)**.
- **Glaciation** resulted in a **major drop in sea level**, killing off all life along the coast.
- Glaciation caused snowball earth, leading to the **Ordovician-Silurian extinction (First Mass Extinction)**.

Ordovician–Silurian extinction (First Mass Extinction)

- This is considered the second deadliest in the history of the earth.
- This event greatly affected marine communities.
- As the southern supercontinent Gondwana drifted over the South Pole, ice caps formed on it.
- A combination of **lowering of sea level and glacially driven cooling** were likely driving agents.

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- A fall in atmospheric carbon dioxide preceded the late Ordovician glaciation event.
- The dip is correlated with a burst of volcanic activity that deposited new silicate rocks, which draw CO_2 out of the air as they erode.

Silurian Period

- The Silurian spans from 440 million years to 415 million years ago.
- This period saw the **mass evolution of fish**.
- The first freshwater fish evolved, though arthropods, such as sea scorpions, remained the apex predators.
- Fully terrestrial life evolved, which included fungi and centipedes.
- The evolution of **vascular plants allowed plants to gain a foothold on land**.

Devonian Period

- Spans from 415 million years to 360 million years ago.
- Also known as the **Age of the Fish**, the Devonian features a massive diversification in fish.
- On land, plant groups diversified; the **first trees and seeds evolved**.
- By the Middle Devonian, **shrub-like forests of primitive plants** existed.
- The **first amphibians** also evolved, and the fish were now at the top of the food chain.
- Near the end of the Devonian, 70% of all species became extinct in an event known as **the Late Devonian extinction**, the second mass extinction known to have happened.

Late Devonian extinction (Second Mass Extinction)

- The Late Devonian extinction occurred about 376–360 million years ago.
- The extinction seems to have only affected marine life.
- The causes of these extinctions are unclear. Leading hypotheses include changes in sea level and **ocean anoxia (lack of oxygen)**, possibly triggered by global cooling or oceanic volcanism.

Carboniferous Period

- Spans from **360 million to 300 million years ago**.
- **Tropical swamps** dominated the earth, and the **large amounts of trees created much of the carbon that became coal deposits** (hence the name Carboniferous).

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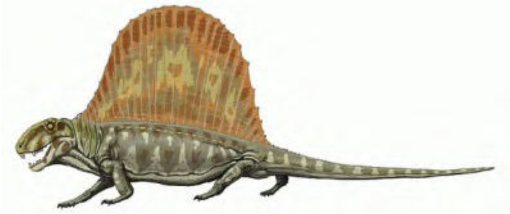
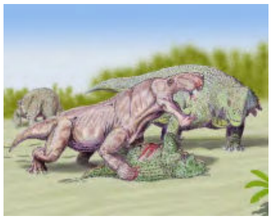
- The **high oxygen levels** caused by these swamps allowed massive arthropods, normally limited in size by their **respiratory systems**, to proliferate.
- Perhaps the most important evolutionary development of the time was the evolution of **amniotic eggs**, which allowed **amphibians** to move farther inland. (Amniotic fluid is a clear, slightly yellowish liquid that surrounds the foetus).
- Also, the **first reptiles** evolved in the swamps.

Permian Period

- Spans from 300 million to 250 million years ago.
- At its beginning, **all continents came together** to form the supercontinent **Pangaea**, surrounded by one ocean called **Panthalassa**.
- The earth was very dry during this time, with harsh seasons, as large bodies of water didn't regulate the climate of the interior of Pangaea.
- **Reptiles** flourished in the new dry climate.
- Creatures such as Dimetrodon and Edaphosaurus ruled the new continent.





- The **first conifers** evolved, then dominated the terrestrial landscape.
- Nearing the end of the period, Scutosaurus and gorgonopsids filled the arid landmass.
- Eventually, they disappeared, along with 95% of all life on earth, in an event simply known as "**the Great Dying**", the world's **third & the largest mass extinction** event.

Permian–Triassic extinction event (Third Mass Extinction)

- The Permian–Triassic (P-T) extinction event is also known as the **Great Dying**.
- It occurred about 252 Ma (million years) ago, forming the boundary between the Paleozoic and the Mesozoic eras.
- It is the earth's **most severe known extinction event**, with up to **96% of all marine species** and **70% of terrestrial vertebrate species becoming extinct**.
- It is the **only known mass extinction of insects**.
- Suggested causes include **large meteor impact events**, **massive volcanism** such as that of the **Siberian Traps**, **runaway greenhouse effect triggered by the sudden release of methane from the seafloor** due to **methane-producing microbes known as methanogens**.
- Possible contributing gradual changes include sea-level change, increasing anoxia, increasing aridity, and a shift in ocean circulation driven by climate change.

9.4.3. Mesozoic Era

- Spans from 250 million to 66 million years ago.
- Also known as "**the Age of the dinosaurs**", the Mesozoic features the **rise of reptiles**.
- There are three periods in the Mesozoic: Triassic, Jurassic, and Cretaceous.

Triassic Period

- Spans from 250 million to 200 million years ago.

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- It is a transitional time between the **Permian Extinction** and the lush Jurassic Period.
- It has three major epochs: Early Triassic, Middle Triassic and Late Triassic.

Early Triassic

- Spans from 250 million to 247 million years ago.
- Deserts dominated **Pangaea** (not yet broken up; thus, the interior was arid).

Supercontinent Pangea

- The earth had just witnessed a massive die-off in which 95% of all life became extinct.
- The most common life on Earth was Lystrosaurus, labyrinthodonts, along with many other creatures that managed to survive the Great Dying.

Middle Triassic

- Spans from 247 million to 237 million years ago.
- The Middle Triassic featured the **beginnings of the breakup of the supercontinent Pangaea** and the **beginning of the Tethys Sea**.
- The ecosystem had recovered from the devastation of the Great Dying.
- Phytoplankton, coral, and crustaceans all had recovered, and the reptiles began increasing in size.
- New aquatic reptiles, such as ichthyosaurs, proliferated in the seas.
- Meanwhile, on land, pine forests flourished, as well as mosquitoes and fruit flies.
- The first ancient crocodilians evolved, which sparked competition with the large amphibians.

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Late Triassic

- Spans from 237 million to 200 million years ago.
- It featured frequent rises in temperature, as well as moderate precipitation.
- The recent warming led to a boom of reptilian evolution on land as the **first true dinosaurs** evolved, as well as pterosaurs.

Dinosaurs and Pterosaurs

- By the end of the period, the first giant dinosaurs had evolved, and advanced pterosaurs colonized Pangaea's deserts.
- The climactic change, however, resulted in a large die-out known as the **Triassic-Jurassic extinction event (Fourth Mass Extinction)**, in which all large amphibians became extinct.

Triassic–Jurassic extinction event (Fourth Mass Extinction)

- It marks the boundary between the Triassic and Jurassic periods, 201 million years ago.
- This event happened in less than 10,000 years and occurred just before Pangaea started to break apart.
- On land, all archosaurs except a few and many of the large amphibians became extinct.
- This event vacated terrestrial ecological niches, allowing the dinosaurs to assume the dominant role.
- Gradual climate change, sea-level fluctuations, **oceanic acidification** reached a tipping point.
- **Massive volcanic eruptions** might have caused **intense global warming (releasing carbon dioxide or sulphur dioxide into the troposphere)** or **extreme global cooling (releasing aerosols into the stratosphere)**.

Jurassic Period

- It spans from 200 million to 145 million years ago and features three major epochs: Early Jurassic, Middle Jurassic, and Late Jurassic.

Early Jurassic

- Spans from 200 million to 175 million years ago.
- The climate was much more humid than the Triassic, and as a result, the **world was very tropical**.
- In the oceans, plesiosaurs, ichthyosaurs and ammonites dominated the seas.
- On land, **dinosaurs and other reptiles dominated the land**.
- The **first true crocodiles** evolved, pushing the large amphibians to near extinction.
- The reptiles rose to rule the world.
- Meanwhile, the **first true mammals evolved** but never exceeded the height of a shrew.

Middle Jurassic

- Spans from 175 million to 163 million years ago.
- During this epoch, dinosaurs flourished.

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- Many other predators rose as well, such as Allosaurus.
- **Conifer forests** made up a large portion of the world's forests.
- In the oceans, plesiosaurs and ichthyosaurs were flourishing.
- This epoch was the **peak of the reptiles**.

Late Jurassic

- Spans from 163 million to 145 million years ago.
- The Late Jurassic featured a **massive extinction of sauropods and ichthyosaurs** due to **the separation of Pangaea into Laurasia and Gondwana** in an extinction known as the **Jurassic-Cretaceous extinction**.
- The increase in sea levels opened up the Atlantic seaway, which would continue to get larger over time.
- The divided world would give an opportunity for the diversification of new dinosaurs.

Cretaceous Period

- It spans from 145 million to 66 million years ago and is divided into two epochs: Early Cretaceous and Late Cretaceous.

Early Cretaceous

- Spans from 145 million to 100 million years ago.
- The Early Cretaceous saw the **expansion of seaways**.
- **Seasons** came back into effect, and the poles grew seasonally colder.
- Since it was too cold for crocodiles, it was the last stronghold for large amphibians.
- In this epoch, Pterosaurs reached their maximum diversity and grew larger.
- The **first true birds evolved**, possibly sparking competition between them and the pterosaurs.

Late Cretaceous

- Spans from 100 million to 65 million years ago.
- The Late Cretaceous featured a cooling trend that would continue into the Cenozoic Era.
- Eventually, tropical ecology was restricted to the equator.
- Dinosaurs still thrived as new species.
- Pterosaurs went into a decline as birds radiated.
- Marsupials evolved within the large conifer forests as scavengers.
- Also, the **first flowering plants** evolved.

Cretaceous–Paleogene extinction event (Fifth Mass Extinction)

- The Cretaceous-Paleogene (K-Pg) or Cretaceous-Tertiary (K-T) extinction was a sudden mass extinction on earth approximately 66 million years ago.
- At the end of the Cretaceous, the **Deccan Traps and other volcanic eruptions were poisoning the atmosphere**.
- As this was continued, it is thought that a large meteor smashed into the earth, creating the **Chicxulub Crater** (Yucatan Peninsula Mexico), creating the event known as the **K-T Extinction**.
- Every living thing with a body mass of over 10 kilograms became extinct, and the **age of the dinosaurs came to an end**.
- In its wake, many groups underwent remarkable adaptive radiation—sudden and prolific divergence into new forms and species.
- **Mammals diversified in the Paleogene**, evolving new forms such as horses, whales, bats, and primates. Birds, fish, and perhaps lizards also radiated.

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9.4.4. Cenozoic Era

- The Cenozoic featured the **rise of mammals** as the dominant class of animals.
- There are three divisions of the Cenozoic: **Paleogene, Neogene** and **Quaternary**.

Paleogene Period

- Spans from the **extinction of the non-avian dinosaurs, some 66 million years ago** **(K-T extinction event)**, to the dawn of the Neogene 23 million years ago.
- It features three epochs: Paleocene, Eocene and Oligocene.

Paleocene

- The Early Paleocene saw the recovery of the earth from the K-T extinction event.
- This epoch featured a general warming trend, and **jungles eventually reached the poles**.
- Sharks dominated the oceans as the giant reptiles that had once ruled became extinct.
- Archaic mammals, such as early **primates** that evolved during the Mesozoic, filled the world.
- **Mammals were still relatively small**; meanwhile, enormous crocodiles and snakes were top predators.

Eocene

- Spans from 56 million to 34 million years ago.
- In the early Eocene, most land mammals were small and living in cramped jungles, much like the Paleocene.
- Among them were early primates, whales and horses, along with many other early forms of mammals.
- **Carnivorous flightless birds** continued to be top predators until their extinction in the Quaternary period.

Oligocene

- Spans from 33 million to 23 million years ago.
- This period featured a **global expansion of grass** which had led to many new species to take advantage, including the first elephants, cats, dogs, marsupials, and many other species still prevalent today.
- Many other species of plants evolved during this epoch also, such as the **evergreen trees**.
- The long-term cooling continued, and seasonal rains patterns were established.
- Mammals continued to grow larger.
- **Paraceratherium**, the **largest land mammal to ever live,** evolved during this epoch.

Neogene Period

- Spans from 23.03 million to 2.58 million years ago.
- It features 2 epochs: the Miocene and the Pliocene.

Miocene

- Spans from 23.03 to 5.333 million years ago.
- **Grass spread** further across **diminishing forests** in the process.

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- Many new plants evolved, and 95% of modern seed plants evolved in the mid-Miocene

Pliocene

- Spans from 5.333 to 2.58 million years ago.
- **Australopithecus evolved in Africa, beginning the human branch**.
- The **isthmus of Panama** formed, and animals migrated between North and South America.
- Climatic changes brought **savannas** that are continuing to spread across the world, **Indian monsoons, deserts in East Asia, and the beginnings of the Sahara Desert**.

Quaternary Period

- Spans from 2.58 million years ago to the present day.
- It features modern animals and dramatic changes in the climate.
- It is divided into two epochs: the Pleistocene and the Holocene.

Pleistocene

- Spans from 2.58 million to 11,700 years ago.
- **Ice ages** marked this epoch as a result of the cooling trend that started in the Mid-Eocene.

- Many animals evolved, including mammoths, dire wolves, and most famously **Homo sapiens**.
- 1,00,000 years ago marked the end of one of the worst droughts of Africa and led to the expansion of primitive man.
- As the Pleistocene drew to a close, a major extinction wiped out much of the world's megafauna, including some of the hominid species, such as **Neanderthals**.

Holocene

- The **Holocene began 11,700 years ago** and lasts until the present day.
- All **recorded history** and "the history of the world" lies within the boundaries of the Holocene epoch.

Holocene extinction (Sixth Mass Extinction or Anthropocene Extinction)

- Human activity is blamed for a **mass extinction that began roughly 10,000 years ago**.
- This is sometimes referred to as the "**Sixth Mass Extinction or Anthropocene Extinction**."
- More than 322 species have become extinct due to human activity since the Industrial Revolution.
- The current rate of extinction of species is estimated at 100 to 1,000 times higher than natural background extinction rates.

Anthropocene Extinction includes:

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- The disappearance of large land animals known as megafauna (e.g., mammoths) due to climate change and overhunting.
- Human predatory (**global super predator**) with worldwide effects on food webs.
- Widespread degradation of highly biodiverse habitats such as coral reefs and rainforests.

9.4.5. Anthropocene epoch

- Officially, humans will continue to live in the **Holocene epoch** (11,700 years ago to the present) for a couple of years more before the **Anthropocene epoch** is finally ratified.
- It will be the first time that the beginning of an epoch would be **based on human activity (anthropogenic)** and not the consequences of changes brought about by nature.
- For instance, the start of the **Holocene epoch 11,700 years ago** marks the end of the **transition from the last glacial phase to a period of warming and a rise in sea level**.

Q. The term "sixth mass extinction/sixth extinction" is often mentioned in the news in the context of the discussion of (2018)

a) Widespread monoculture practices in agriculture and large-scale commercial farming with indiscriminate use of chemicals in many parts of the world that may result in the loss of good native ecosystems.
b) Fears of a possible collision of a meteorite with the earth in the near future in the manner it happened 65 million years ago that caused the mass extinction of many species, including those of dinosaurs.
c) Large scale cultivation of genetically modified crops in many parts of the world and promoting their cultivation in other parts of the world which may cause the disappearance of good native crop plants and the loss of food biodiversity.
d) Mankind's over-exploitation/misuse of natural resources, fragmentation/loss of natural habitats, destruction of ecosystems, pollution and global climate change.

Answer: d)

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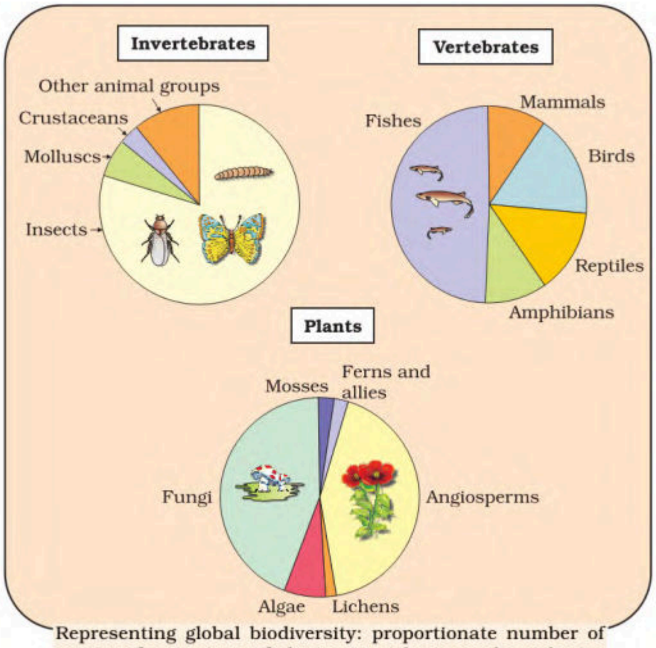
10. Biodiversity and Loss of Biodiversity

- Biodiversity refers to the **variety** of plant, animal, and microbial species plus all the genetic variations in the world or in a particular habitat.
- About **8.7 million** is the estimated total number of species on earth, with **6.5 million species on land** and **2.2 million in oceans**.
- A staggering 86% of all species on land and 91% of those in the seas have yet to be discovered!
- A large proportion of the species waiting to be discovered are in the **tropics**.
- Only about 1.2 million species have been formally described, the vast majority being from the land.
- More than **70 per cent** of all the species recorded are **animals**, while plants (including algae, fungi, bryophytes, gymnosperms, and angiosperms) comprise no more than 22 per cent of the total.
- Among animals, **insects are the most species-rich taxonomic group**, making up more than **70 per cent of the total**.
- The **tropical Amazonian rainforest** in South America has the most extraordinary biodiversity on earth.



Representing global biodiversity: proportionate number of species of major taxa of plants, invertebrates and vertebrates

10.1. Definitions

10.1.1. Biodiversity

- Biodiversity underpins all life on earth and refers to biological variety in all its forms, from the genetic makeup of plants and animals to cultural diversity. – WHO
- Biodiversity is measured by two major components: **species richness** and **species evenness**.

Species richness

- It is the measure of the **number of species** found in a community.
- **Tropical rainforests** in the terrestrial ecosystem and **coral reefs** in the marine ecosystem have the highest degree of species richness.

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Types of Species

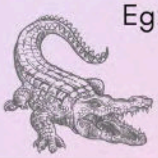
Keystone Species

It is a species whose **addition to or loss** from an ecosystem leads to **major changes** in the **occurrence of at least one other species.**

If keystone species is **lost**, it will result in the **degradation of the whole ecosystem.**

Considered more important in **determining the presence of many other species** in that ecosystem.

Eg: **Top Level Predators**



Indicator Species

It is the one who's **presence or absence or abundance** reflects the environmental condition.

They serve as **early warning mechanism or signals** because they are **sensitive** to environmental conditions.

Also Known as **Sentinel Species.**

Eg: **Frogs, Lichens, Salmon**

Endemic Species

They are **native to a single specific geographical location** such as an island, state, nation, country or other defined zone

A rare alternative term for a species that is endemic is '**precinctive**' (species that are restricted to a defined geographical area).

Eg: Western Ghats -> Lion-tailed macaque
Eg: Western Ghats -> Nilgiri Tahr
Eg: Eastern Himalayas -> Red Panda
Eg: Eastern Ghats -> Flying Squirrel
Eg: Eastern Ghats -> Civet

Invasive Alien Species

An Exotic Species which is **introduced in an area (Intentionally or Unintentionally).**

Once introduced they **multiply so rapidly** that they destroy the local habitat of an area.

Eg: Lantana, Fall Army Worm, Eucalyptus, Wattle, Prosopis Juliflora, Common Water Hyacinth

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Flagship Species

It is a species chosen to **represent an environmental cause**, such as an ecosystem in need of conservation.

These species are chosen for their **vulnerability, attractiveness or distinctiveness** in order to engender support and acknowledgement from the public at large.

Eg: Indian Tiger, African Elephant, Giant Panda of China, Kangaroo of Australia

Umbrella Species

The Species that are **selected for the conservation of an entire ecosystem** and forms an important part of National Parks and Wildlife Sanctuaries.

Eg: **Tigers** and **Giant Pandas** are an example of an umbrella species.

Efforts to save wild tigers in forests also accomplish the goal of saving other species there, such as leopards, boars, hares, antelopes, and monkeys.

Foundational Species

Foundation species is a **dominant primary producer in an ecosystem** both in terms of abundance and influence.

It is the species that creates or maintains an ecosystem.

Eg: Kelp in kelp forests
Eg: Corals in coral reefs.

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Species evenness

- Species evenness is a measure of the **relative abundance of the different species** making up the richness of an area.
- Example: Sample forest A has 2 tigers, 5 deer and 6 rabbits and sample forest B has 1 tiger, 6 deer and 8 rabbits. Both samples have the same richness (3 species – species richness) and the same total number of individuals (15). However, sample forest A has more evenness than sample forest B.
- **Low evenness indicates that a few species dominate the site**.

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Alpha diversity

- It refers to the diversity within a particular area or ecosystem and is usually expressed by the **number of species (i.e., species richness)** in that ecosystem.

Beta diversity

- It is a comparison of diversity between ecosystems, usually measured as the **change in the number of species between the ecosystems**.

Gamma diversity

- It is a measure of the **overall diversity of the different ecosystems within a region**.

10.1.2. Genetic diversity

- Genetic diversity is the **total number of genetic characteristics in the genetic makeup of a species**.
- A single species might show high diversity at the genetic level (E.g., *Homo sapiens*: Chinese, Indian American, African etc.)

India has more than 50,000 genetically different strains of rice and 1,000 varieties of mango.

- Genetic diversity allows species to **adapt to changing environments**.
- Genetic diversity ensures that some species **survive drastic changes** and thus **carry on desirable genes**.
- **Species that differ from one another in their genetic makeup do not interbreed in nature**.
- Closely related species have in common much of their hereditary characteristics. For instance, about 98.4 per cent of the genes of humans and chimpanzees are the same.

10.1.3. Species diversity

- It is the ratio of one species population over total number of organisms across all species in the given biome. '**Zero' would be infinite diversity**, and '**one' represents only one species present**.
- Species diversity is a measure of the diversity within an ecological community that incorporates **both species richness (the number of species in a community)** and the **evenness of species**.
- In general, **species diversity decreases as we move away from the equator towards the poles**.
- With very few exceptions, tropics (latitudinal range of 23.5° N to 23.5° S) harbour more species than temperate or polar areas.

10.1.4. Ecological diversity

- Ecological diversity refers to **different types of habitats**.
- A habitat is the cumulative factor of the climate, vegetation and geography of a region.
- It includes various biological zones, like a lake, desert, coast, estuaries, wetlands, mangroves, coral reefs etc.
- At the ecosystem level, India, for instance, with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows, has a greater ecosystem diversity than a Scandinavian country like Norway.

Stable community

- A stable community means that there is **not much variation in productivity** from year to year.
- It is either resistant or **resilient to occasional disturbances** (natural or human-made) and is **resistant to invasions by alien species**.

10.1.5. Endemism

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- Endemism is the **ecological state of a species being unique to a defined geographic location**, such as an island, nation, country or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere.
- A particular type of animal or plant may be endemic to a zone, a state or a country.
- The extreme opposite of endemism is **cosmopolitan distribution**.

10.1.6. Bioprospecting & Biopiracy

- Bioprospecting as a term refers to the **exploration of biodiversity** for **commercially valuable genetic resources** and **biochemicals**.
- **Bioprospecting** as an activity refers to **deriving products of economic importance** by nations endowed with **rich biodiversity** by exploring their **molecular, genetic, and species-level diversity**.
- Some in the west pass off **biopiracy** as **bioprospecting**.
- **Biopiracy** occurs when "**genetic resources and traditional knowledge is taken from biodiverse developing countries without permission**."
- Moreover, the **stolen traditional knowledge** is **used to benefit the non-indigenous people** through a patent or product with no compensation or gain received by the indigenous people.
- **Biopiracy of India's "genetic resources and traditional knowledge"** by advanced economies and large corporations is a matter of great concern.

10.1.7. Types of Species

Keystone species

- **Keystone species** is a species **whose addition to or loss from an ecosystem leads to major changes in the occurrence of at least one other species**.
- Keystone species **determine the presence of many other species** in that ecosystem.
- **All top predators (Tiger, Lion, Crocodile)** and key species like **elephants, corals** and **pollinators** and are considered **keystone species** because they **regulate all other animal populations** indirectly. For example, certain plant species (ebony tree, Indian laurel) exclusively depends upon **bats for their pollination**.
- If the bat population is reduced, then regeneration of plants becomes more difficult.
- If keystone species is lost, it will result in the **degradation of the whole ecosystem**.
- Hence **top predators** are given much consideration in conservation.

Foundation species

- Foundation species is a **dominant primary producer** in an ecosystem both in terms of abundance and influence.
- Example: **kelp (large brown algae seaweeds) in kelp forests** and **corals in coral reefs**.

Flagship species

- A flagship species is a species **chosen to represent an environmental cause**, such as an ecosystem in need of conservation.
- These species are chosen for their **vulnerability, attractiveness or distinctiveness** in order to engender support and acknowledgement from the public at large.
- Example: **Indian tiger, African elephant, giant panda of China**, the **leatherback sea turtle**, etc.

10.2. Importance of a Healthy Biodiversity

Support a variety of plant species

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- With greater biodiversity, the variety of plants increases.
- This leads to more opportunities, especially for farmers, since they are able to plant a greater variety of crops.

Ecosystem balance

- If only a small number of species die out, there can be a huge effect on the whole ecosystem since there are often chain effects in the **food web**.
- With the preservation of biodiversity, it can be assured that the ecosystem stays in its natural balance.

Breaking down pollutants

- Through the process of photosynthesis, plants help to break down pollutants and thus clean the air.
- In areas with a high wood and plant density, air quality tends to be much better than in areas with a low concentration of plants.

Climatic stability

- Since our natural system is balanced and if we do not intervene too much, biodiversity protects the planet from global warming.
- For example, the **rainforests store huge amounts of CO_2**, which is classified as a greenhouse gas.

10.3. Causes for the Loss of Biodiversity

- The IUCN Red List (2004) documents the extinction of 784 species in the last 500 years.
- Some examples of recent extinctions include the three subspecies of tigers (**Bali, Javan, Caspian**).
- During the long period (> 3 billion years) since the origin and diversification of life on earth, there were **five episodes of mass extinction of species**.
- The **Sixth Extinction (anthropogenic)** presently is in progress, with current species extinction rates estimated to be 100 to 1,000 times faster than in pre-human times.
- Ecologists warn that if the present trends continue, nearly half of all the species on earth might be wiped out within the next 100 years.

Global Assessment Report on Biodiversity and Ecosystem Services 2019

- **UN-sponsored Global Assessment Report on Biodiversity and Ecosystem Services 2019** report is prepared by the **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)**, based in Bonn, Germany.
- IPBES comprises 130 member countries, including India.
- **IPBES** examines **scientific literature on biodiversity**.
- Hence, IPBES is often described as the "**IPCC for biodiversity**".

Key points from the IPBES Report

- The total estimated number of species on earth is **8 million** (includes **5.5 million insect species**).
- Nearly half of the natural ecosystems have already vanished due to human activities.
- Up to **1 million species are threatened with extinction**, many within decades.
- The threatened list includes **40% of amphibian species**, **33% of reef-forming corals**, and more than a **third of all marine mammals**.
- Humans have severely altered 75% of the land, 40% of marine environments and 50% of inland waterways:
- 300% increase in food crop production since 1970.
- **23%** of land areas have seen a reduction in productivity due to **land degradation**.

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- 50% agricultural expansion occurred at the expense of forests.
- 100-300 million people in coastal areas are at increased risk due to loss of coastal habitat protection.
- More than 100% growth of urban areas since 1992.
- Less than 1% of total land is used for mining but has significant negative impacts on the environment.
- **16-21 cm rise in global average sea level since 1900**.
- **100% increase since 1980 in GHG emissions**, raising the average global temperature by **0.7 degrees**.
- Plastic pollution alone has increased tenfold since 1980.
- 1,000 green activists and journalists reporting on environmental issues killed between 2002 and 2013.

- Natural ecological disturbances, such as weather, wildfire, floods, and volcanic eruptions, change ecosystems drastically by eliminating local populations of some species.
- Such disturbances are temporary because natural disturbances are common, and ecosystems have adapted to their challenges (ecological succession).
- Permanent biodiversity loss is typically associated with **mass extinction events** and **anthropogenic ecological changes**.
- There are four major anthropogenic causes for the loss of biodiversity – **The Evil Quartet – Habitat loss, Overexploitation, Alien species and Secondary extinction.**

10.3.2. Habitat Loss and Fragmentation

- This is the most important cause of driving animals and plants to extinction.
- Wetlands are being made dry through landfills as the demand for land increases.
- Natural forests are cleared for industry, agriculture, dams, habitation, recreational sports, etc.
- The most dramatic examples of habitat loss come from tropical rainforests.
- Once covering **more than 14 per cent of the earth's land surface**, these rain forests now cover **no more than 6 per cent**.
- The **Amazon rain forest** (called the '**lungs of the planet**'), probably harbouring millions of species, is being cleared for **cultivating soybean** or for **conversion to grasslands for raising beef cattle (ranching)**.

Barrier Effect and Associated Long-term Ecological Damage

- Habitat fragmentation **increases the risk of inbreeding**.
- Inbreeding is the mating of organisms closely related by ancestry.
- It goes against the biological aim of mating, which is the shuffling of DNA.
- **Inbreeding limits the gene pool** and creates **inbreeding depression**, which means population decreases due to a lack of healthy mates, and there is an increased risk of **local extinction**.
- Genes in DNA fall into two categories, dominant and recessive.
- If one of the genes in the pair is dominant, then the result is that the animal/organism gains the trait of the dominant gene.
- However, for traits that originate from the recessive gene, the organism needs both genes to be recessive.
- This is important as certain **congenital defects, and genetic diseases** in both humans and animals are **carried by recessive alleles**.
- Inbreeding increases the risk of offsprings being born with such conditions since the chances of parents carrying the same recessive gene are greatly increased.
- For example, inbreeding in koalas in Australia has put the entire species at the risk of **local extinction** by just one disease.

Fragmentation of India's Tiger Habitats

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- According to an estimate, around 55,000 km of roads pass through India's forests and protected areas.
- GOI will construct a 36 km-long flyover above **NH 37**, which passes through the **Kaziranga National Park**.
- **NH 44** cuts through corridors connecting **Kanha, Satpura, Pench, Bandhavgarh & Panna tiger reserves**.
- **NH 6** — India's second-longest highway that runs from Surat to Kolkata — passes through corridors around **Melghat, Bor, Nagzira, Simlipal tiger reserves**.
- Dozens of roads are being upgraded on these stretches with no mitigation measures in place.

Effect on tiger population

- Central India's tigers have the **highest genetic variation** among Indian tigers.
- This has been made possible by the large habitats available here in the past.
- When populations are isolated by linear projects, there's the **risk of inbreeding of disease and local extinction**.

Grassland Habitat Loss in the Western Ghats due to Invasive Species

- The Shola vegetation is **tropical montane forests** found in the Western Ghats separated by rolling **grasslands** in high altitudes (upper Nilgiris with peaks and plateaus ranging from 1,700 to 2,600 metres).

- Owing to the altitude, the Shola patches occur only in the folds of the mountains that receive the least fog.
- Invasive species like **eucalyptus, tea plantations**, **wattle (acacia), Lantana,** and naturalized alien species like **Parthenium hysterophorus** in the Nilgiris are wiping out Shola forests.
- **Frost** traditionally restricted the forests in the Nilgiris from expanding as it freezes the groundwater and stops the sapling from sprouting in new areas.
- Over the years, the nights have become warmer, and the amount of frost has reduced in the Nilgiris.
- This has allowed the acacia plantations to move beyond the **Shola forests** and enter the **grasslands**.
- This change in vegetation is resulting in loss of water sources, causing massive landslides and have deprived the original habitat of endangered species like **Nilgiri Tahr (**EN**)**.

Toda Tribes

- Toda tribes are a Particularly Vulnerable Tribal Group settled in the **upper Nilgiris**.
- The pastoral Toda community's livelihood is entirely dependent on the **Shola grasslands**.

10.3.3. Alien Species Invasions

- Invasive alien species are **non-native species** that **spread and interfere in a new ecosystem** by posing a serious threat to the native biodiversity, leading to economic loss.
- They are the **second-biggest cause for biodiversity loss, next to habitat destruction.**
- When invasive species are introduced into an ecosystem, they may not have any natural predators or controls, and native wildlife may not have evolved defences against the invading species.
- A resin-like substance that oozes from such alien plant species **makes the soil acidic**, preventing the growth of any other plant species.

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- Species like **Lantana** grow extensively & create a **mat-like structure**. As a result, herbivores like **Gaur, Chital** and **Sambar** are deprived of their food.
- The **Nile perch** fish introduced into Lake Victoria in East Africa led eventually to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish in the lake.
- You must be familiar with the environmental damage caused and the threat posed to our native species by invasive weed species like:
  - **carrot grass (Parthenium), Argemone,**

  - **Lantana** and **water hyacinth**.

- The presence of **house gecko** has negatively impacted native gecko populations throughout tropical Asia.
- The colonization of tropical Pacific Islands by humans is said to have led to the extinction of more than 2,000 species of native birds.

How are invasive species introduced into an ecosystem?

- Invasive species are primarily spread by human activities like transportation.
- Ships can carry aquatic organisms in their ballast water and on their propellers.
- Insects can get into wood that are shipped around the world.
- Some ornamental plants can escape into the wild and become invasive.
- Sometimes, humans voluntarily introduce an invasive species to control the population of another species.
- In addition, changes in rain and snow patterns caused by climate change will enable some invasive plant species to move into new areas.

Threats to native wildlife from invasive species

- The direct threats of invasive species include:
  - ✓ preying on native species,
  - ✓ outcompeting native species for food or other resources,
  - ✓ causing or carrying disease, and
  - ✓ preventing native species from reproducing or killing a native species' progenies.
- There are indirect threats of invasive species as well.
  - ✓ They can **change the food web** by destroying or replacing native food sources.
  - ✓ They may provide little to no food value for wildlife.
  - ✓ Aggressive plant species can quickly replace a diverse ecosystem with a **monoculture**.
  - ✓ Additionally, some invasive species are capable of changing soil chemistry or the intensity of wildfires.

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Acacia (wattle) and eucalyptus

- Species such as **Eucalyptus, Wattle (Acacia)**, introduced from **Australia**, have become highly invasive.
- Acacias have almost replaced the grasslands in the **Nilgiris**, which sustained cattle for centuries.
- The government introduced acacia in the region after India stopped importing **tannin** from Africa in the 1960s.
- Tannin, found in the bark, pods and leaves of acacia, is an organic substance used for **preserving leather**.

African catfish

- The **banned African catfish (invasive species)** is illegally reared and sold in Kerala and Tamil Nadu.
- Factoring in the health & environmental hazards posed by the **African catfish**, the Central government issued a **ban on catfish farming (Breeding, transportation and sale)** in 2000.
- The **veraciously carnivorous fish** was **posing a threat to indigenous fish varieties**.
- It can destroy the native fish species by preying on them, besides feeding on **microscopic zooplankton**.
- Native to **Africa and the Middle East,** where it inhabits freshwater lakes, rivers, swamps, and urban sewage systems, the African catfish was introduced all over the world in the early 1980s for aquaculture.
- Its ability to survive in **shallow mud for long periods of time**, high **tolerance for poorly oxygenated water**, and **fast breeding give** it an edge over other native species.
- Inland fishers prefer catfish as they grow faster and fetch a good price.
- Many of the farms use chicken waste as feed, polluting water sources and the environment.
- Experts feel that the ban would have little effect unless the existing stocks are destroyed.

Forked Fanwort

- In some places in Kerala, the widespread growth of **forked fanwort** has painted the water bodies **pink**.
- It is a submerged **perennial aquatic plant** that grows in stagnant to slow-flowing freshwater.
- It is an **invasive species** that belongs to **Central and South America**.
- It requires a considerable amount of **oxygen** to grow, & that could badly affect freshwater biodiversity.

Indian Bullfrog

- It is a large species of frog found in mainland **Myanmar, Bangladesh, India, & Nepal.**
- It has been introduced in Madagascar & **India's the Andaman Islands**.
- It is now a widespread **invasive species**.
- They prefer **freshwater wetlands** & **aquatic habitats** (generally, they avoid coastal & forest areas).
- This species is classified as **LC in the IUCN red list**.

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Prosopis Juliflora

- In the 1960s, the government introduced **Prosopis juliflora (ganda babool)** in the **Banni grasslands region** to fight **salinity** and to **stop the advancement of the Rann of the Kutch**.
- It was done without evaluating the ecological and socio-economic consequences.
- The plant thrived in the non-saline and low saline soils and **invaded the Banni grasslands**.
- The plant also **takes away all rechargeable water and aggravates the droughts** in the region.
- To the Maldhari herders of the Kutch region, this has meant a huge loss of pastures.
- But it has also meant unexpected income: **Prosopis charcoal**.
- **Prosopis juliflora** wood has high carbon content; **charcoal derived from it is in high demand**.
- **Prosopis charcoal** has helped **Maldharis** substitute grass with market-bought fodder during dry seasons.

Banni grasslands

- The Banni grasslands are natural grasslands spanning 2,617 sq km in the **Kutch region**.
- Banni grasslands used to be one of the finest **natural grasslands** in India.
- Overgrazing, droughts, salinity ingress, invasion by **Prosopis juliflora shrub** and encroachment for agricultural activities have destroyed the grasslands.
- They are currently legally protected under the status as a protected forest in India.
- Wildlife Institute of India has identified Banni as one of the last remaining habitats of the **cheetah** in India.
- The Indian Wild Ass (NT) population, which had become confined to nearby **Little Rann of Kutch**, has been increasing in numbers and has started spilling over into adjoining areas, including Banni Grasslands.

Indian Wild ass / khur

- IUCN Red List Status: **Moved from Endangered (2015) to Near Threatened (2019)**.

- Today, its last refuge lies in the **Indian Wild Ass Sanctuary**, Little Rann of Kutch.
- Threats: Diseases, habitat degradation due to salinity ingress, Invasive species **Prosopis juliflora**, and encroachment and grazing by the **Maldharis**.

Maldharis

- Maldharis are a pastoral community of Kutch that depended on the Banni Grasslands for their livelihood.
- They have developed tolerant breeds of livestock such as the **kankrej, the Banni buffalo**, and **the kharai camel**.

- In the 1960s, the Maldhari community's main livestock population included cows.

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- But cows could not adapt to **Prosopis juliflora**. So, they shifted to **Banni buffaloes**.
- The **Banni buffaloe** is a breed famous for its **(high fat) milk quality** and drought resistance.
- Only 33 per cent of the biomass harvested from Banni is suitable for cattle. The rest is weed.
- This has affected the quality of milk as well the livelihood of Maldharis.

Q. Why is a plant called Prosopis juliflora often mentioned in news? (2018)

a) Its extract is widely used in cosmetics.
b) It tends to reduce the biodiversity in the area in which it grows.
c) Its extract is used in the synthesis of pesticides.
d) None of the above

Answer: b)

Q. A sandy and saline area is the natural habitat of an Indian animal species. The animal has no predators in that area, but its existence is threatened due to the destruction of its habitat. Which one of the following could be that animal?

a) Indian wild buffalo
b) Indian wild ass
c) Indian wild boar
d) Indian Gazelle

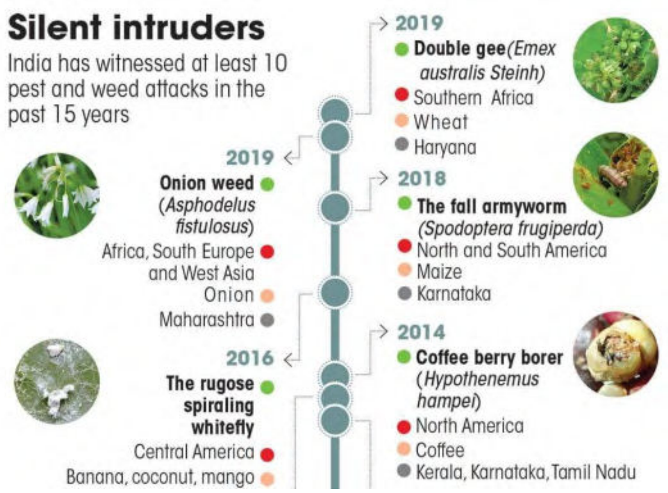
Explanation:

- Sandy saline area ➔ Kutch region.
- Indian wild buffalo ➔ Terai region.
- Indian wild boar ➔ can survive in different types of habitat: grasslands, taiga, tropical rainforests, but they prefer life in deciduous forests.
- Chinkara (Indian gazelle) ➔ Thar desert.

Answer: b) Indian wild ass

Invasive Pest and Weed Attacks in India

- In the past 15 years, India has faced at least 10 major invasive pest and weed attacks.
- The most recent was the **fall armyworm** that destroyed almost the entire maize crop in 2018.



10.3.4. Over-exploitation

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- When human 'needs' turns to 'greed', it leads to over-exploitation of natural resources.
- In the last 500 years, many species extinctions (Steller's Sea cow, **passenger pigeon**) was due to overexploitation by humans.
- Presently many marine fish populations around the world are over-harvested, endangering the continued existence of some commercially important species.
- Whales for oil, fish for food, trees for wood, plants for medicines etc., are being removed by humans at higher rates than they can be replaced.
- Excessive cutting of trees, overgrazing, collection of firewood, hunting of wild animals for skin (for example, tigers from reserve forests of India), ivory etc., all result in **gradual loss of species**.

Poaching

- Large mammals such as the tiger, rhinoceros and the elephant once faced the distinct possibility of complete extinction due to rampant hunting and poaching.
- Global warming (Climate change), natural calamities are other reasons for the loss of biodiversity.

10.3.5. Species Extinction

- Extinction is caused through various processes:
  1) **Deterministic processes** that have a cause and effect. E.g., glaciations, human interference such as deforestation.
  2) **Stochastic processes** (chance and random events) affect the survival and reproduction of individuals. E.g., unexpected changes in weather patterns decreased food supply, disease, increase of competitors, predators or parasites, etc., that may act independently or add to deterministic effects.
- The impact of these processes will, of course, depend on the size and degree of genetic diversity and resilience of populations.
- Traits that adversely affect or increase a species vulnerability to extinction due to habitat fragmentation have been identified. These are:
  - ✓ rarity or low abundance
  - ✓ poor dispersal ability
  - ✓ **high trophic status** – as animals occupying a higher trophic level (i.e., the position of a species in a food chain) usually have smaller populations than those at lower levels (e.g. carnivores are fewer in number than herbivores)
  - ✓ low adult survival rates

Co-extinctions

- When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct.
- When a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate.
- Another example is the case of a **coevolved plant-pollinator mutualism** where extinction of one invariably leads to the extinction of the other.

10.3.6. Genetically Modified Organisms (GMO/Transgenic Organism)

- In GMOs, genetic material (**DNA**) is **altered or artificially introduced** using genetic engineering techniques like **mutation, insertion, or deletion of genes.**
- Inserted genes usually come from a **different organism** (e.g., In Bt cotton, Bt genes from bacterium **Bacillus thuringiensis** are induced).
- Genetic modification is done to induce a **desirable new trait** that does not occur naturally in the species.

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- The most common trait engineered into GMO crops is that they **generate toxins** within the plant cells.
- These toxins can be **far more potent than expected** and can **remain in the environment** for far too long.
- GMO species can become dominant and can overrun the existing species, thereby reducing biodiversity.
- Unintended transfer of transgenes through cross-pollination can cause unknown effects on other organisms (e.g., soil microbes) and lead to loss of biodiversity.
- Also, most GMO crops are engineered for herbicide resistance, so weedkillers are liberally sprayed.
- Weeds are a problem, but diverse plant life also protects the soil from erosion and nutrient loss.
- It supports the pollinators and other beneficial insects that do so much of the agricultural labour.
- While "welcoming the weeds" is not a practical solution, neither is wiping out plant life with toxic chemicals.

The Curious Case of Genetically Modified Mosquitoes

- In the absence of an effective vaccine for dengue fever, Zika fever, chikungunya and other mosquito-borne diseases, researchers are exploring genetic strategies to reduce mosquito populations.
- A company called Oxitec developed **GM male mosquitoes (GM strain of Aedes aegypti)**.
- These male GM mosquitoes are said to have a **"self-limiting" gene**.
- It means that when these so-called friendly mosquitoes mate, their **offspring inherit the self-limiting gene,** which is supposed to prevent them from surviving into adulthood.
- In theory, when these mosquitoes are released in high numbers, a dramatic reduction in the mosquito population should follow.
- With approval from Brazilian authorities, Oxitec released nearly half a million GM mosquitoes every week into the environment over a two-year period from 2013 to 2015.
- Studies have since confirmed that some of the offspring of the GM mosquitoes did not succumb to the self-limiting lethal gene and survived to adulthood.
- They were able to breed with native mosquitoes and **thereby introduced some of their genes into the wild population**.
- One significant worry is that a new breed of mosquito might emerge that is more difficult to control.
- Thus, like GM soybean or corn, there is legitimate concern about the **propagation of new genetic material in wild populations** with as yet unknown consequences.

10.3.7. Trade in Wildlife

- Many species of wildlife are threatened by unsustainable harvest and trade.
- The unsustainable use of wildlife creates a risk both for biodiversity conservation and for local livelihoods.
- Illegal wildlife trade contributes to habitat destruction, which **removes necessary buffer zones** between humans and wild fauna, making it more likely that animal pathogens come into contact with people.
- Specimens that are traded illegally are also much less likely to be sold or bought where sanitary standards are being properly enforced, making the spread of diseases more likely, thereby reducing local biodiversity.

10.3.8. Pollution and Climate Change

- Marine biodiversity is affected by **ocean acidification** related to levels of carbon in the atmosphere.
- Terrestrial biodiversity is influenced by **climate variability** such as extreme weather events (i.e., drought, flooding).
- Longer-term changes in climate affect the viability and health of ecosystems, influencing shifts in the distribution of plants, pathogens, animals, and even human settlements.

10.4. Consequences of Loss of Biodiversity

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10.4.1. Affects Livelihood

- Human health depends on **ecosystem products & services** (such as the availability of freshwater, food, fuel).
- Changes in ecosystem services affect livelihoods, income, local migration and, on occasion, may even cause or exacerbate political conflict.
- Loss in biodiversity may limit the discovery of potential treatments for many diseases and health problems.

Food and Nutritional Security Crisis

- Biodiversity plays a crucial role in human nutrition through its influence on world food production, as it ensures the sustainable productivity of soils and provides the **genetic resources** for all crops, livestock, etc.
- Nutrition and biodiversity are linked at many levels: the ecosystem, with food production as an ecosystem service; the species in the ecosystem and the **genetic diversity** within species.
- Intensified food production through irrigation, fertilizer use, plant protection (pesticides) or the introduction of crop varieties and cropping patterns affect biodiversity and thus impact global nutritional status. Healthy local diets, with adequate average levels of nutrients intake, necessitates the maintenance of high biodiversity levels.

10.4.2. Human-Animal Conflict

- Human-animal conflict refers to the interaction between wild animals and people and the **resultant negative impact** on people or their resources, or wild animals or their habitat.
- It occurs when wildlife needs overlap with those of human populations, creating costs to residents and wild animals.

Causes

- Human population growth and encroachment into forest lands.
- Land use transformation – industrialization, infrastructure development, commercial farming etc.
- Species habitat loss, degradation and fragmentation due to above-mentioned reasons.
- Increasing livestock populations and competitive exclusion of wild herbivores.
- Growing interest in **ecotourism** and increasing access to nature reserves.
- Abundant distribution of prey in the form of livestock on the **periphery** of forest lands.
- Increasing wildlife population as a result of conservation programmes.
- Climate change-induced habitat destruction.
- **Stochastic events** (e.g., fire, floods etc.)

Impacts

- Crop damage and damage to property.
- Livestock depredation: Himalayan snow leopard preys on goats in the Himalayan region. Farmers trap and kill snow leopards to save their livestock.
- Injuries & deaths: Man eater tigers are reported to have injured and killed villagers living on the periphery.
- Injuries to wildlife: leopards and other wild animals are hacked to death by mobs.

Preventive and Mitigation strategies

- Artificial and natural barriers (physical and biological) – very expensive.
- Guarding – very expensive.
- Alternative high-cost livestock husbandry practices.
- Relocation: voluntary human population resettlement.
- Waste management systems that restrict wildlife access to refuse.
- Community-based natural resource management schemes (CBNRMS)

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Project RE-HAB

- **RE-HAB Project** is an innovative way of **preventing elephant–human conflicts**.
- It is demonstrated by **Khadi & Village Industries Commission's (KVIC)**.
- The project has significantly reduced elephants' presence at places in Karnataka's Kodagu district.
- It will soon be replicated in all states affected by elephant attacks like **West Bengal, Jharkhand, Odisha, Chhattisgarh, Assam, Tamil Nadu & Kerala**.
- Under this project, **bee boxes are used as a fence** to prevent elephants from entering human habitation.
- Elephants fear that the honeybees might sting them in their eyes & the inner side of the trunk.
- Also, the buzz of the bees irritates the elephants the most.
- Bee fences have reduced the movement of elephants at these points to a great extent.
- The uniqueness of Project RE-HAB is that **it does not cause any harm** to both humans and elephants.

Culling of animals – Conservation or Biodiversity loss?

Natural culling

- Culling means 'Selection'.
- In the wild, it is the process of weeding out the weak.
- A population boom makes individuals compete for food and safety, and the weaker ones lose out, leaving a smaller population of more able individuals.
- Culling naturally occurs by starvation, disease and predation. It is **nature's way of controlling the population**.

Culling by humans – controlled culling

- In the post-conservation era, human intervention became necessary for the management of wildlife populations through controlled hunting, which is now referred to as culling.

Why did controlled culling become necessary?

- Human-Animal conflict – too many wild animals compete with humans for resources.
- Threat to life and livelihood (crop, property damage) makes culling necessary.
- Loss of forestland to mines, industry, agriculture, etc., is the primary reason behind the man-animal conflict.
- Crop-raiding by smaller herbivores due to a population boom & animals raiding nutrient-rich crops like wheat, maize are other major reasons for man-animal conflict.

The practice of Culling worldwide

- In the US, some areas require seasonal culling to ease pressure on livestock feed.
- In parts of Africa, culling has been used for commercial harvesting.
- Australia culls feral cats to protect native species.
- Australia also culls kangaroos. Recently Australia culled camels to regulate their overpopulation.

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Animal Welfare Activists vs Pro Culling Lobby

- Culling lobby: Affected farmers and government administration.

Arguments by animal welfare activists against culling	Arguments by Culling lobby
• Ethical grounds: humans do not have the right.	• They support a practical and realistic approach.
• They believe that every individual animal is ethically indispensable, even at the cost of putting entire species at risk.	• Conservationists are concerned about the integrity of the ecosystem and the future of the entire species.
• Culling is against animal conservation.	• Culling is for conservation. • By law, wildlife is protected because they are too few and require protection. • But when certain pockets see a population boom in herbivores, farmers cannot wait for predators to reoccupy such areas. • The absence of lawful intervention **often triggers retaliation by illegal means**. • In anger, farmers may **indiscriminately target wildlife**, including those that may not be causing any problem.
• Culling can increase people's apathy (lack of interest or enthusiasm) for the conservation of other forms of life. • (Some people recruited to cull animals post their pictures along with their prey on social media. This glorifies killing an animal.)	• No concrete evidence to prove that culling increases insensitivity among people. • (But practically it does. A lot of people enjoy hunting animals, and others might take inspiration from culling)
• They argue thathuman-animal conflict can be controlled through non-invasive means, including a) fencing crop fields, b) planting chilli around cropland, c) creating buffer areas between croplands and the forest's edge, d) selecting non-edible crops, e) providing adequate and regular compensation for crop loss, etc.	• Fencing merely shifts conflict to the next accessible cropland. • Fencing is expensive and its maintenance is not effective. • Even the selection of crops that traditionally repelled animals does not seem to work any longer. • For example, farmers in Sirmour, Himachal Pradesh, now complain that monkeys raid garlic fields that they avoided until recently. • Other measures are mostly long-term and can keep a check on conflict only in situations where crop damage is still reasonable. • But in pockets where the situation is already out of hand, the only option is often to reduce the number of habitual crop-raiders.

10.4.3. Increased Zoonoses due to Habitat Loss

- **Zoonoses (zoonotic diseases) are diseases transmitted from animals to humans**.
- E.g., **Rabies (dogs), Ebola (fruit bats), novel coronavirus Covid-19 (pangolin)**, etc.
- Zoonoses are opportunistic and thrive where there are changes in the environment, changes in animal populations that serve as hosts for certain pathogens, or changes in the pathogen itself.
- Zoonotic diseases are closely interlinked with the **health of ecosystems**.
- According to the **UN Environment Programme (UNEP)**, 60% of human infectious diseases are zoonotic.
- **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)** estimates that zoonoses kill some 700,000 people a year (the current COVID-19 not considered).

How does the change in ecosystems and loss of biodiversity help Zoonoses thrive?

- Ecosystems are inherently resilient, and by supporting diverse species, they help regulate diseases.
- The less biodiverse an ecosystem gets, the easier it is for a pathogen to spread rapidly.

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- By destroying forests for agriculture, industries, etc., humans fragment and encroach into animal habitats.
- This brings wildlife close to human settlements as the **natural buffer** that would generally separate humans from animals is destroyed.
- This creates opportunities for pathogens to spill over from wild animals to humans.

10.4.4. Adverse Changes to Biotic Interactions

- Even though a species may not have been eliminated from the ecosystem, its **niche (the role the species play in the ecosystems it inhabits)** diminishes as its numbers fall.
- If the niches filled by a single species or a group of species are critical to the proper functioning of the ecosystem, a sudden decline in numbers may produce significant changes in the ecosystem's structure.
- For example, clearing trees from a forest eliminates the shading, temperature and moisture regulation, animal habitat, and nutrient transport services they provide to the ecosystem.

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11. Biodiversity Conservation

- Conservation of biological diversity leads to the conservation of essential **ecological diversity** to preserve the continuity of food chains.
- The **genetic diversity** of plants and animals is also preserved.
- Biodiversity conservation assures sustainable utilization of potential resources and constant flow of ecosystem services and goods.
- When we conserve and protect the whole ecosystem, its biodiversity at all levels is protected. E.g., we save the entire forest to save the tiger. This approach is called **in-situ (on-site) conservation**.
- However, when there are situations where an animal or plant is endangered or threatened and needs urgent measures to save it from extinction, **ex-situ (off-site)** conservation is the desirable approach.

11.1. In situ conservation

- In-situ conservation is the **on-site conservation** of genetic resources in natural populations of plant or animal species.
- In India, ecologically unique and biodiversity-rich regions are legally protected as **biosphere reserves, national parks, sanctuaries, reserved forests, protected forests** and **nature reserves**.
- India now has **18 biosphere reserves, 104 national parks and** 550+ wildlife sanctuaries.
- **Plantation, cultivation, grazing, felling trees, hunting** and **poaching** are **prohibited** in **biosphere reserves, national parks** and **wildlife sanctuaries**.
- **National Board for Wildlife (NBWL)**, chaired by the **Prime Minister of India,** provides for a policy framework for wildlife conservation in the country.
- The **National Wildlife Action Plan** (2002-2016) was adopted in 2002, emphasizing the people's participation and their support for wildlife conservation.

11.1.1. Reserved & Protected Forests

- As of present, reserved forests and protected forests differ in one crucial way:
  - ✓ **Rights to all activities like hunting, grazing**, etc., in **reserved forests,** are **banned** unless specific orders are issued otherwise.
  - ✓ In **protected forests**, rights to activities like hunting and grazing are **sometimes given to communities living on the fringes of the forest**, who sustain their livelihood from forest resources or products.
- The first reserve forest in India was **Satpura National Park** in Madhya Pradesh.
- Typically, reserved forests are often upgraded to the status of **wildlife sanctuaries**, which in turn may be upgraded to the status of **national parks**, with each category receiving a **higher degree of protection** and **government funding**.

In terms of protection, National Parks > Wildlife Sanctuary > Reserved forests > Protected forests

11.1.2. Wildlife Sanctuaries or Wildlife Refuges

- Wildlife Sanctuaries or wildlife refuges are **home to various endangered species**.
- They are safe from hunting, predation, or competition.
- **Endangered species** are safeguarded from extinction in their **natural habitat**.
- **Certain rights of people living inside the Sanctuary could be permitted**.
- **Grazing, firewood collection by tribals is allowed but strictly regulated**.

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- **Settlements are not allowed (few exceptions:** tribal settlements do exist; constant efforts are made to relocate them).
- A Sanctuary can be promoted to a **National Park**.

Tiger Reserves

- Their protection status is the **same as wildlife sanctuaries**. But they are **monitored by NTCA (Project Tiger)**.
- The various tiger reserves were created in the country based on **core buffer strategy**.

11.1.3. Biosphere Reserve

- Biosphere reserves are large areas of protected land for the **conservation of wildlife, plant** and **animal resources** and **traditional life of the tribals** living in the area.
- **It may have one or more national parks or wildlife sanctuaries in it**.

Core area

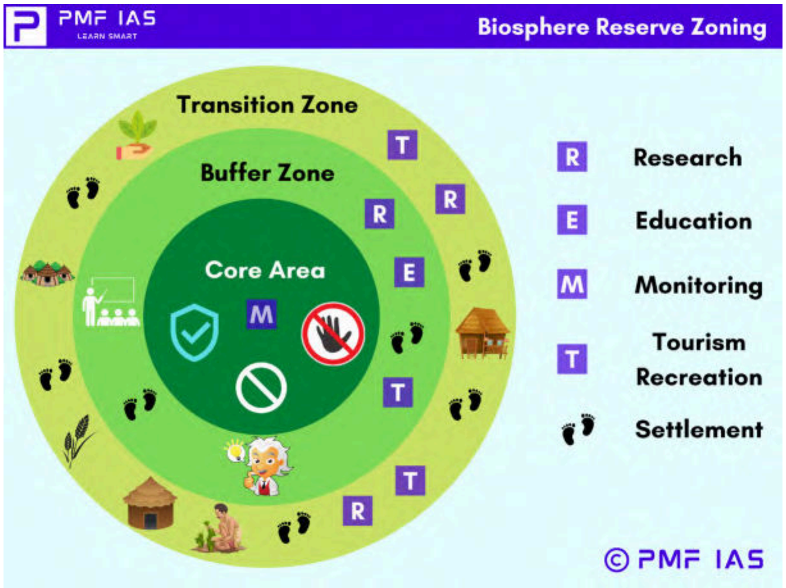
- Comprises a strictly protected ecosystem for conserving ecosystems, species and genetic variation.
- In the core or natural zone, **human activity is not allowed**.

Buffer zone

- Used for scientific **research, monitoring, training, and education**.
- **Limited human activity** is permitted in the buffer zone.

Transition area

- **Ecologically sustainable human settlements and economic activities (tourism) are permitted**.
- With the cooperation of reserve management and local people, several human activities like **settlements, cropping, recreation**, and **forestry** are carried out without disturbing the environment.



11.1.4. National Park

- National parks are areas **reserved for wildlife** where they can freely use their habitats and natural resources.
- The difference between a Sanctuary and a National Park mainly lies in the **vesting of rights of people living inside**.
- **Unlike a Sanctuary, where certain rights can be allowed, in a National Park, no rights are allowed**.

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- **No grazing of any livestock shall also be permitted inside a National Park** while in a **Sanctuary; the Chief Wildlife Warden may regulate, control or prohibit it**.

Q. The most important strategy for the conservation of biodiversity together with traditional human life is the establishment of

a) biosphere reserves
b) botanical gardens
c) national parks
d) wildlife sanctuaries

Explanation:

- **National Parks and Wildlife Sanctuaries discourage all sorts of human activity**.
- **In Wildlife Sanctuaries, grazing of cattle is strictly regulated**.

Answer: a)

11.1.5. Eco-Sensitive Zones (ESZs) or Ecologically Fragile Areas (EFAs)

- **Eco-Sensitive Zones (ESZs)** are areas notified by the MoEF **around Protected Areas**, **National Parks & Wildlife Sanctuaries**.
- The National Wildlife Action Plan (2002–2016) of MoEFCC stipulated that **state governments** should declare land falling **within 10 km of the boundaries of national parks and wildlife sanctuaries as eco-fragile zones or ESZs** under the **Environmental (Protection) Act, 1986**.
- The purpose of the ESZ was to provide more protection to the parks by acting as a **shock absorber or transition zone**.
- The width of the ESZ & type of regulation may vary from protected area to area.
- Eco-Sensitive Zones would **minimize forest depletion** and **man-animal conflict**.
- They areas are based on the **core and buffer model of management**.
- The **core area has the legal status of being a national park**.
- The **buffer area, however, does not have legal status of being a national park** and **could be a reserved forest, wildlife sanctuary or tiger reserve**.
  - ⇨ *Recently, the **Bhagirathi Eco-Sensitive Zone (4179.59 sq km) notification** from **Gaumukh to Uttarakashi** was issued by MoEF.*

Legal Status

- The **Environment (Protection) Act, 1986 does not mention** the word **"Eco–Sensitive Zones"**.
- Section 3(2)(v) of the Act says that GOI can restrict areas in which any industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards.
- Besides the **Environment Rules, 1986** states that GOI can prohibit or restrict the location of industries.
- The above two rules have been effectively used by the government to declare ESZs or EFAs.

Activities Allowed in ESZs

- **Prohibited:** commercial mining, setting of sawmills & industries causing pollution, commercial use of firewood & major hydropower projects, are prohibited in such areas.
- It also prohibits tourism activities like flying over protected areas in an aircraft or hot air balloon & discharge of effluents & solid waste in natural water bodies or terrestrial areas.

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- **Regulated**: felling of trees, drastic change in agriculture systems & commercial use of natural water resources, including groundwater & setting up of hotels & resorts, are the activities regulated in the areas.
- **Permitted**: ongoing agriculture & horticulture practices by local communities, rainwater harvesting, organic farming, adoption of green technology & use of renewable energy sources.

Q. With reference to 'Eco-Sensitive Zones', which of the following statements is/are correct?

1) Eco-Sensitive Zones are the areas that are declared under the Wildlife (Protection) Act, 1972.
2) The purpose of the declaration of Eco-Sensitive Zones is to prohibit all kinds of human activities, in those zones except agriculture.

Select the correct answer using the code given below.

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Explanation:

- Eco-Sensitive Zones areas are based on the **core (all kinds of human activity are prohibited)** and **buffer (grazing, collection of minor forest produce, subsistence agriculture, etc. are allowed on a sustainable basis)** model of management.

Answer: d) Neither

11.1.6. Conservation Reserves

- **Conservation Reserves** can be declared by the **State Governments** in **any area owned by the government**, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another.
- Such a declaration should be made after having consultations with the **local communities**.
- The **rights of people living inside a Conservation Reserve** are **not affected**.

11.1.7. Community Reserves

- **Community Reserves** can be declared by the **State Government** in **any private or community land, not comprised within a National Park, Sanctuary or a Conservation Reserve, where an individual or a community has volunteered to conserve wildlife and its habitat**.
- As in the case of a Conservation Reserve, the rights of people living inside a Community Reserve are **not affected**.

11.1.8. Sacred Groves

- India has a history of religious/cultural traditions that emphasized the protection of nature.
- In many cultures, tracts of forest were set aside, and all the trees and wildlife within were venerated and given total protection.
- Such sacred groves are found in **Khasi** and **Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghat regions of Karnataka and Maharashtra and the Sarguja, Chanda and Bastar areas of Madhya Pradesh**.
- In Meghalaya, the sacred groves are the last refuges for a large number of rare and threatened plants.

11.2. Ex Situ Conservation

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- In this approach, threatened animals and plants are **taken out from their natural habitat** and placed in a unique setting where they can be protected and given special care.
- **Zoological parks, botanical gardens, wildlife safari parks** and **seed banks** serve this purpose.
- There are many animals that have become extinct in the wild but continue to be maintained in zoological parks.
- In recent years ex-situ conservation has advanced beyond keeping threatened species.
- Now **gametes** of threatened species can be preserved in viable and fertile conditions for long periods using cryopreservation techniques.
- Eggs can be fertilized in vitro, and plants can be propagated using tissue culture methods.
- Seeds of different genetic strains of commercially important plants can be kept for long periods in **seed banks**.
- The **national gene bank** at the **National Bureau of Plant Genetic Resources (NBPGR), Delhi,** is primarily responsible for the conservation of unique accessions on a long-term basis, as base collections for posterity, predominantly in the form of seeds.

11.2.1. Botanical Garden

- A botanical garden refers to the scientifically planned collection of living trees, shrubs, herbs, climbers and other plants from various parts of the globe.
- It augments **conserving rare and threatened species**.

Purpose of botanical gardens

- To study taxonomy as well as the growth of plants.
- To study the introduction and acclimatization process of exotic plants.

11.2.2. Zoo

- A zoo is an establishment where captive animals are kept for exhibition to the public and includes a circus and rescue centres but does not include an establishment of a licensed dealer in captive animals.
- The initial purpose of zoos was entertainment. Over the decades, zoos have transformed into centres for wildlife conservation (through captive breeding) and environmental education.

Q. Which one of the following is not a site for in-situ method of conservation of flora?

a) Biosphere Reserves
b) Botanical Garden
c) National Park
d) Wildlife Sanctuary

Explanation:

- Botanical Garden: Plants are bred in a protected environment far from their natural home, especially for research purposes. So, it's ex-situ conservation.
- Rest all along with protected forests, and reserved forests are in-situ conservation methods.

Answer: b) Botanical Garden

11.3. National Efforts and Initiatives for Biodiversity Conservation

11.3.1. Wildlife Mitigation Measures – Eco-Bridges or Eco-Ducts

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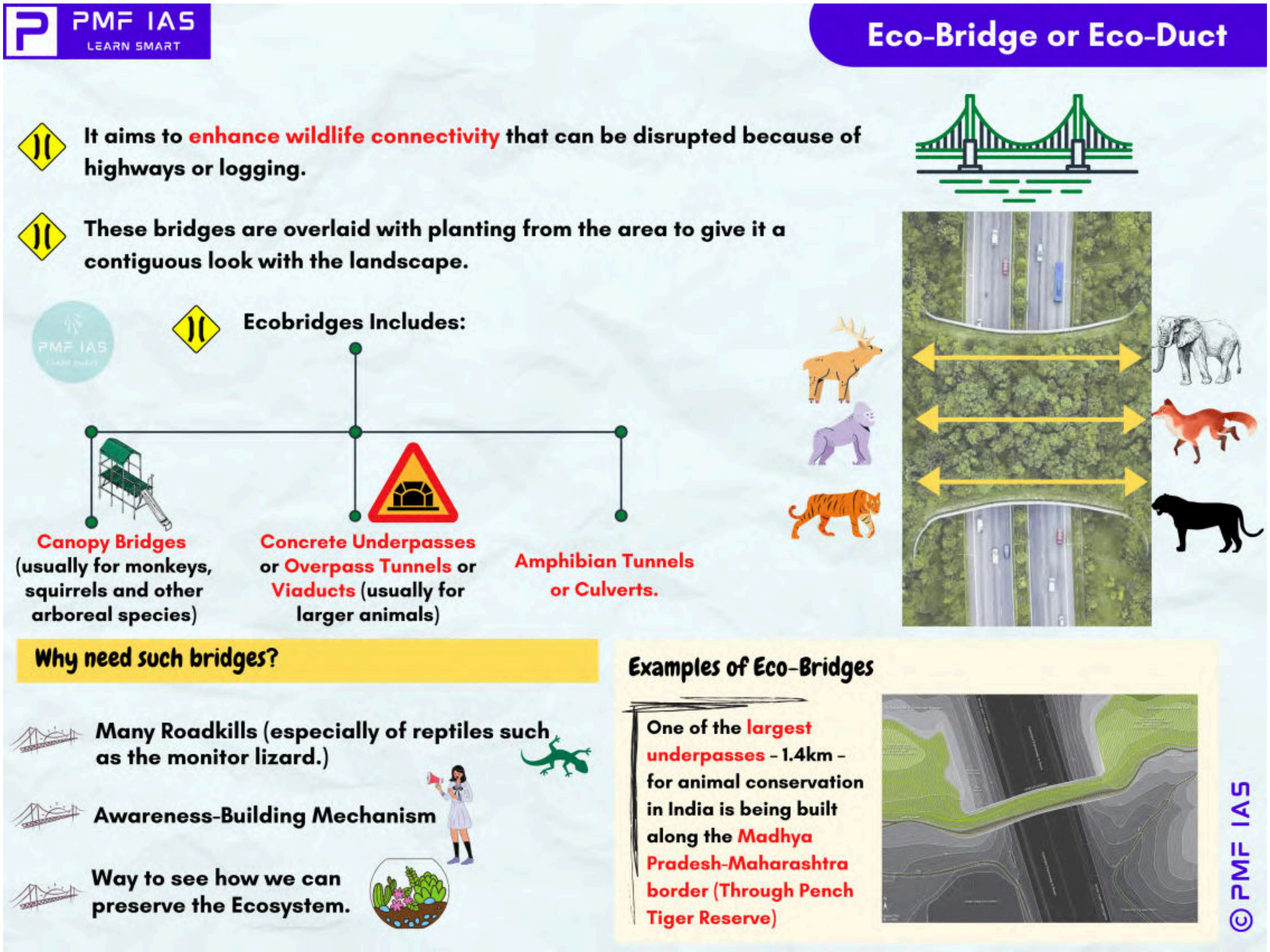

- Conservationists use a range of techniques to help increase connectivity in fragmented landscapes.
- These include creating corridors, buffers and eco-bridges to help wildlife move around.
- **Eco-bridges** aim to **enhance wildlife connectivity**, which can be disrupted because of highways or logging.
- Eco-bridges include:
  1. **canopy bridges** (usually for monkeys, squirrels & other arboreal species);
  2. **concrete underpasses or overpass tunnels** or **viaducts** (usually for larger animals); &
  3. **amphibian tunnels** or **culverts**.
- Usually, these bridges are overlaid with planting to give it a contiguous look with the landscape.

11.3.2. Quarantine Centres to Check Invasive Species

- Countries have animal, plant and health quarantine facilities at all transborder entry points.
- India has 108 plant quarantine centres located at major airports, seaports and railway stations.
- The quarantine centres are under the control of the **Central Board of Indirect Taxes & Customs**, which works in co-ordination with the **Directorate of Plant Protection & Quarantine Storage (DPPQS)**.
- The import of agricultural products is governed by the **Destructive Insects and Pests act, 1914**.
- **The Ministry of Agriculture & Farmers Welfare (MAFW)** is responsible for the **control of invasive pests & weeds**.
- MAFW has also prepared lists of plants whose import is allowed, restricted or banned.
- There is also a list of weeds that should not enter the country with any import.

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- When an agricultural product arrives, customs officials check if it has a **phytosanitary certificate** or not.
- This certificate, showing that the product is without any pest or weed infestation, is issued by the government of the exporting country. If the product is certified, **it is cleared by DPPQS after a sample test**.
- If the product has not been given a phytosanitary certificate, DPPQS fumigates the product with **methyl bromide (gas fumigant for soil-borne diseases and pests)** and issues a phytosanitary certificate.

Issues with the functioning of the quarantine centres

- Only half of India's quarantine centres are functional.
- The rest are shut down as the import-export is negligible or because of staff shortage.
- Customs officials often release the cargo without referring it to DPPQS. Nepal, for instance, stopped the entry of agriculture products from India without a phytosanitary certificate after the outbreak of acute encephalitis syndrome in Bihar a year ago.
- Corruption is pervasive in DPPQS. The officials take bribes to clear the products without objections.
- The security at India's quarantine stations is also virtually non-existent, and items disappear in transit.

11.3.3. Preservation of the Western Ghats and the Eastern Ghats

- Western and Eastern Ghats play an irreplaceable role in mediating the monsoon over the country, and the forests harbour **rich biodiversity**.
- Human encroachment, tourism, deforestation, sand mining, iron mining (Goa), etc., are posing serious threats to the ecosystem of the ghats.

Western Ghats

- Western Ghats (1.6 lakh sq km in area) run from Kanyakumari to Gujarat, spanning **six** different States — **Maharashtra, Karnataka, Tamil Nadu, Kerala, Gujarat** and **Goa**.
- The Western Ghats exhibits a remarkably high degree of species endemism.
- It is one of the eight "hottest hotspots" of biological diversity in the world.
- It is a **UNESCO World Heritage Site**.

Eastern Ghats

- The Eastern Ghats are spread across ~75,000 sq km and run from northern **Odisha** through **Andhra Pradesh** to **Tamil Nadu** in the south, passing some parts of **Karnataka** and **Telangana**.
- Unlike the western Ghats, these are **discontinuous hills** as they are eroded and cut through by Godavari, Mahanadi, Krishna, and Kaveri rivers.
- Eastern ghats also boast tourist hotspots such as sanctuaries, national parks, hills, rivers and waterfalls.
- Deforestation has made the hills of the Eastern Ghats barren, and its streams are running dry.
- Large-scale plantations of coffee, tea and orchards have been raised in these hills.
- Valuable trees like **sandal** (from **Seshachalam Hills**) are removed illegally.

Madhav Gadgil Committee

- The MoEF constituted the **Western Ghats Experts Ecology Panel (WGEEP)** in 2010.
- The Panel submitted its report in 2011 with a **stringent assessment** of the condition of Western Ghats.
- The report suggested many **radical changes** that need to be brought to conserve the Western Ghats.
- The recommendations, if implemented, would severely affect the mining mafia, sand mafia and local encroachers.
- It was criticized that the committee **failed to find a balance between development** and **conservation**.

Gadgil Committee (WGEEP) Recommendations

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- The report had recommended **64% of the area come under Ecologically Sensitive Area (ESA)**.
- Within this area, smaller regions were to be identified as **ecologically sensitive zones (ESZ) I, II or III** based on their existing condition and vulnerability.
- **75 per cent would fall under ESZ I or II** or under already existing protected areas such as or natural parks.
- **No new dams** based on large-scale storage should be permitted in **ESZ I**.
- **No new polluting industries**, including thermal power plants, should be allowed in **ESZ I and II**.
- The existing **red and orange category industries** should be asked to switch to zero pollution by 2016.
- It asked for a **bottom to top approach,** i.e., from Gram sabhas to top, rather than a top to bottom approach.
- The committee proposed a **Western Ghats Ecology Authority** with **statutory powers** to regulate these activities in the area.

Kasturirangan Committee

- Under pressure from various stakeholders, MoEF had set up the **High-Level Working Group (HLWG)** under the Chairmanship of **Dr K. Kasturirangan** to study recommendations of the Gadgil Committee.
- The HLWG had **diluted** many recommendations of WGEEP to satisfy the interests of the various mafia.
- HLWG had suggested that **37% (60,000 hectares) of the Western Ghats should be declared as ESA**.

Recommendations of Kasturirangan Committee

- A ban on mining, quarrying and sand mining.
- No new thermal power projects, but hydro power projects allowed with restrictions.
- A ban on new polluting industries.
- Building and construction projects up to 20,000 sq m was to be allowed but townships were to be banned.
- Forest diversion could be allowed with extra safeguards.

October 2018 notification

- To protect the **Western Ghats**, the MoEF has notified ~57,000 sq km of the Western Ghats spread along with six states as **ecologically sensitive areas (ESA)**.
- The draft notification, if it gets final clearance, will ban activities such as **the** operation of
  - ✓ **red category industries,**
  - ✓ **construction of thermal power plants,**
  - ✓ **large scale construction, mining, quarrying & sand mining**.
- However, hydropower projects, orange category industries and other existing activities will be allowed.
- Angry at repeated delays in finalizing the **Eco-sensitive Zones (ESZ) of the Western Ghats**, the NGT has set a March 2020 deadline for the MoEF. However, the draft notification has not received approval to date.

11.3.4. Historic Citizen Movements to Conserve Biodiversity

- **Environmentalist Sundarlal Bahuguna** who led the **Chipko & Tehri dam movements,** breathed his last due to COVID – 19 in 2021.
- **Sundarlal Bahuguna** is known as **Defender of the Himalayas** & **Environmental Gandhi**.
- He joined Freedom Struggle in his initial years & opened schools for untouchables.
- He protested for the preservation of forests in the **Himalayas** & led the **Chipko Movement** in the 1970s & the **Anti-Tehri Dam movement** starting in the 1980s.
- He was a follower of **Gandhian Principles** like **Satyagraha, non-violence, self-reliance** etc.
- He believed that **'Ecology is the permanent economy'**.

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Chipko Movement

- Chipko means 'To Hug'.
- It is a social-ecological movement that practised the **Gandhian methods of satyagraha** and nonviolent resistance through the **act of hugging trees to protect them from falling**.
- The first recorded event took place in Khejarli Village, Jodhpur, in 1730 AD.
- **363 Bishnois,** led by **Amrita Devi,** sacrificed their lives while **protecting Khejri trees**.

- **Khejri trees (The state tree of Rajasthan)** are considered sacred by the **Bishnoi community**.
- The **first Chipko movement in independent India** took place in April 1973 in **Upper Alakanada valley (Garhwal Region in Uttarakhand** (back then it was in UP)) when the government had allotted land inside forest territory to a manufacturer.

Role of Sunderlal Bhaguna

- Sunderlal Bhaguna travelled 5000 km on foot from village to village, **gathering support** for the movement.
- He had a meeting with Indira Gandhi & that resulted in **15 years ban on cutting green trees in 1980**.

Role of Women in the Movement

- A woman named Gaura Devi came to notice that local loggers are cutting trees in Reni Village.
- She mobilized other women and confronted & challenged them to shoot her instead of cutting trees.
- She described trees & forests as **Vandevta (God of Forest)** & **Maika (Motherhouse)**.
- Therefore, Chipko Movement is aptly called as **Women's Movement**.
- By the 1980s, the movement had spread throughout India and led to the formulation of people-sensitive forest policies, which stopped the open felling of trees in regions as far-reaching as the Western Ghats.

Appiko Movement

- Appiko is a **local term** for **Hugging** in **Kannada.**
- The movement was inspired by the massive success of the Chipko Movement in North India.
- It first started in Karnataka in 1983. It gave birth to a new awareness all over southern India.

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Anti-Tehri Dam Protest

- Tehri Dam is a 2,400-megawatt multipurpose dam on the **Bhagirathi River** (a tributary of the Ganga in Uttarakhand).
- It is **India's Tallest Dam**.
- Tehri Dam lies in the Himalayas Seismic Gap, **i.e., a Major fault zone** (prone to landslides, earthquakes).
- Floods can cause massive **damage to downstream** public life.
- Sunderlal Bahuguna was instrumental in protests against the construction of **Teri Dam** (Garhwal region, Uttarakhand).

Chipko Movement

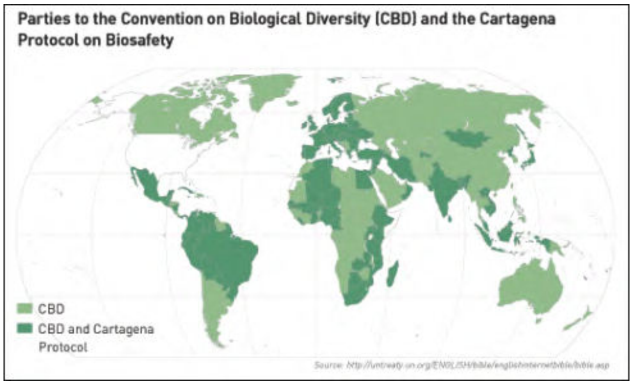
- The first recorded event of Chipko, however, took place in village Khejarli, Jodhpur district, in 1730 AD, when 363 Bishnois, led by Amrita Devi, sacrificed their lives while protecting green Khejri trees, considered sacred by the community, by hugging them.

11.4. International Efforts and Initiatives for Biodiversity Conservation

11.4.1. UN Convention on Biological Diversity (CBD)

- Convention on Biological Diversity (CBD) is a step towards conserving biological diversity or biodiversity with **the involvement of the entire world**.
- The Convention on Biological Diversity (**a multilateral treaty**) was opened for signature at the **Earth Summit in Rio de Janeiro in 1992** and entered into effect in 1993.
- The convention called upon all nations to take appropriate measures for the conservation of biodiversity and **sustainable utilization** of its benefits.
- The convention has three main goals:
  1) **conservation of biological diversity (or biodiversity);**
  2) **sustainable use of its components, and**
  3) **fair and equitable sharing of benefits arising from genetic resources.**
- It is often seen as the key document regarding **sustainable development**.
- The convention is **legally binding**; countries that join it ('Parties') are obliged to implement its provisions.
- Parties to the Convention: 195 states and the European Union. All UN member states — **with the exception of the United States** — have ratified the treaty.
- At the 10th Conference of Parties (COP10 2010) to the Convention on Biological Diversity in Nagoya, Japan, the **Nagoya Protocol** was adopted.

Cartagena Protocol



- CBD covers the field of **biotechnology** through its **Cartagena Protocol on Biosafety**.
- It addresses technology development and transfer, benefit-sharing and biosafety issues.

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- The **Biosafety Protocol seeks to protect biological diversity** from the potential risks posed by living modified organisms resulting from modern biotechnology.
- **Cartagena Protocol** (signed in Cartagena, Colombia) was adopted in 2000 as a supplementary agreement to the Convention on Biological Diversity and entered into force in 2003.

Nagoya Protocol

- The **Nagoya Protocol** is about "**Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization**", one of the three objectives of the CBD.
- It is the **second Protocol to the CBD**; the first is the **2000 Cartagena Protocol on Biosafety**.
- It entered into force in 2014.

International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA)

- Popularly known as the **International Seed Treaty**.
- International agreement in harmony with the **Convention on Biological Diversity**.
- It aims at **guaranteeing food security** through the **conservation, exchange,** and **sustainable use of the world's plant genetic resources for food and agriculture** (PGRFA), as well as the **fair and equitable benefit sharing arising from its use**.

Q. Consider the following pairs (2016):

Terms sometimes seen in the news	Their origin
1) Annex-I Countries	Cartagena Protocol
2) Certified Emissions Reductions	Nagoya Protocol
3) Clean Development Mechanism	Kyoto Protocol

Which of the pairs given above is/are correctly matched?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Explanation:

- **Annex-I Countries, Clean Development Mechanism, Certified Emission Reductions (CERs) or carbon credits ➔ Kyoto Protocol**.

Answer: c) 3 only

Q. Consider the following international agreements:

1) The International Treaty on Plant Genetic Resources for Food and Agriculture
2) The United Nations Convention to Combat Desertification
3) The World Heritage Convention

Which of the above has/have a bearing on the biodiversity?

a) 1 and 2 only
b) 3 only,
c) 1 and 3 only
d) 1, 2. and 3

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Answer: d) all

Aichi Biodiversity Targets

- At Convention on Biological Diversity COP 12 (2014), parties discussed the implementation of the **Strategic Plan for Biodiversity 2011-2020** and its **Aichi Biodiversity Targets**.
- **Aichi Biodiversity Targets** were to be achieved before 2020.
    1. Strategic Goal A: Address the underlying **causes of biodiversity loss** by mainstreaming biodiversity across government and society.
    2. Strategic Goal B: Reduce the direct pressures on biodiversity and **promote sustainable use**.
    3. Strategic Goal C: To **improve the status of biodiversity** by safeguarding ecosystems, species and genetic diversity.
    4. Strategic Goal D: Enhance the **benefits to all from biodiversity** and ecosystem services.
    5. Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building.
- **None of the 20 'Aichi Biodiversity Targets'** agreed on by national governments through the UN Convention on Biological Diversity (CBD) **has been met**, according to CBD's Global Biodiversity Outlook 5 report.

Sharm El Sheikh Declaration

- Sharm El is a city in Egypt, also called the city of peace.
- COP 14 of CBD adopted this declaration.
- The declaration focuses on investing in biodiversity for people & the planet by integrating biodiversity in legislative & policy frameworks.
- It aims to develop a **post-2020 global biodiversity framework** to achieve the **2050 vision for biodiversity** known as **New Deal for Nature**.

COP-15 of the UN Convention on Biological Diversity

- CBD COP15 was originally scheduled to take place from 15-28 October 2020 in Kunming, China.
- It was rescheduled to 11-24 October 2021, in Kunming, Yunnan Province, China.
- **CBD COP15** serves as the **tenth Meeting of the Parties to the Cartagena Protocol on Biosafety** and the **fourth Meeting of the Parties to the Nagoya Protocol on Access and Benefit-sharing**.
- CBD COP 15 will review the achievement of the **CBD's Strategic Plan for Biodiversity 2011-2020 (Aichi Biodiversity Targets)**.
- The final decision on the post-2020 global biodiversity framework will be taken in COP15.

United for Biodiversity Coalition by EU

- The **European Commission** (EU's executive branch) has launched the **'United for Biodiversity'** coalition.
- It was launched on **World Wildlife Day 2020 — the 3rd of March**.
- The coalition is made up of zoos, aquariums, botanical gardens, national parks, and natural history and science museums from around the world.
- The coalition offers the opportunity for all such institutions to "boost public awareness about the nature crisis, ahead of the **COP-15** of the **Convention on Biological Diversity in Kunming, China in Oct 2021**.

11.4.2. World Heritage Sites

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- World Heritage Sites means "Sites any of various areas or objects inscribed on the United Nations Educational, Scientific, and Cultural Organization (**UNESCO**) World Heritage List".
- The sites are designated as having **outstanding universal value** under the **convention concerning the Protection of the World Cultural and Natural Heritage**.
- This convention, which was adopted by UNESCO in 1972 (and enforced in 1975) provides a framework for international cooperation in preserving and protecting **cultural treasures and natural areas**.
- The convention defines the kind of sites which can be considered for inscription to the **World Heritage list** (ancient monuments, museums, **biodiversity**, and geological heritage).
- It sets out the duties of the State Parties in identifying potential sites and their role in protecting them.

"Natural heritage sites are restricted to those natural areas that

1) furnish outstanding examples of the earth's record of life or its geologic processes.
2) provide excellent examples of ongoing ecological and biological evolutionary processes.
3) contain natural phenomena that are rare, unique, superlative, or of outstanding beauty

or

1) furnish **habitats or rare endangered animals** or plants or are sites of exceptional biodiversity".
2) There are ten criteria for cultural heritage and natural heritage.
3) Nominated sites must be of "outstanding universal value" and meet at least one of the criteria below.

International Year of Biodiversity

- The United Nations declared 2010 to be the International Year of Biodiversity.
- It is a celebration of life on earth and of the value of biodiversity for our lives.

Slogan

"Biodiversity is variety of life on earth
Biodiversity is life.
Biodiversity is our life".

11.4.3. Man and Biosphere Programme (MAB programme)

- Man and Biosphere Programme (MAB) was first started by **UNESCO** in 1971.
- It was iater introduced in India in 1986.
- **Aim:** Studying the effects of human interference and pollution on the biotic and abiotic components of ecosystems and conservation the ecosystems for the present as well as future.
- **The main objectives of the MAB programme are to:**
  - ✓ conserve representative samples of the ecosystem.
  - ✓ provide long term **in situ conservation of genetic diversity**.
  - ✓ provide opportunities for education and training.
  - ✓ provide appropriate sustainable managements of the living resources.
  - ✓ promote infer national cooperation.

11.4.4. Decade on Ecosystem Restoration

- The **United Nations General Assembly** has proclaimed **2021–2030 as the Decade on Ecosystem Restoration**, following a proposal for action by over 70 countries from all latitudes.
- **UNEP**, **FAO** and many partners across the planet will work towards 2021-2030 ecosystem restoration.

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- This globally coordinated response to habitat degradation will focus on **global cooperation to restore degraded ecosystems**, contributing to efforts to combat climate change and safeguard biodiversity, food security, and water supply.
- The Work planned for 2021–2030 will contribute to achieving targets set by international conventions and agreements such as the
  - ✓ 2030 Agenda for Sustainable Development**,**
  - ✓ **Strategic Plan for Biodiversity 2020 and Aichi Biodiversity Targets,**
  - ✓ UN Framework Convention on Climate Change**,**
  - ✓ Paris Agreement**,**
  - ✓ UN Convention to Combat Desertification**, Land Degradation Neutrality, the Land Degradation Neutrality (LDN) target setting programme,**
  - ✓ Ramsar Convention**,**
  - ✓ **Global Partnership on Forest and Landscape Restoration (GPFLR),**
  - ✓ **Global Restoration Council and the UN Strategic Plan for Forests 2017– 2030.**

11.4.5. Global Partnership on Forest and Landscape Restoration (GPFLR)

- GPFLR is a global network initiated by **IUCN** to unite governments, organizations, communities and individuals working towards a common goal: **to restore the world's lost and degraded forests and their surrounding landscapes**.
- Specifically, the GPFLR responds directly to the **Bonn Challenge to restore 150 million hectares of deforested and degraded land by 2020 and 350 million hectares by 2030**.

Bonn Challenge

- The **Bonn Challenge**, launched in 2011, aims to bring **150 million hectares (mha)** of the world's **deforested and degraded land into restoration by 2020**.
- In 2014, at the UN Climate Summit, countries extended this target to **350 mha by 2030** under the **New York Declaration on Forests**.
- The New York Declaration on Forests (NYDF) is a **voluntary and non-binding international declaration** to take action to halt global deforestation.
- At the **UNFCCC 2015 in Paris**, India joined the **voluntary Bonn Challenge** pledge to bring into restoration
  - ✓ **13 million hectares of degraded and deforested land by the year 2020, and**
  - ✓ **additional 8 million hectares by 2030**.

11.4.6. United Nations Strategic Plan for Forests 2017–2030

- The agreement on the first-ever UN Strategic Plan for Forests was forged at a special session of the **UN Forum on Forests** held in 2017 and provides an ambitious vision for global forests in **2030**.
- The plan was adopted by the **UN General Assembly**.
- The Strategic Plan features a set of **six Global Forest Goals** and 26 associated targets to be reached by **2030**, which are voluntary and universal.
- It includes a target to **increase forest area by 3% worldwide by 2030**, signifying an increase of **120 million hectares**.

11.4.7. Biodiversity Finance Initiative (BIOFIN)

- It was launched by **UNDP in 2012**.
- **It aims to:**

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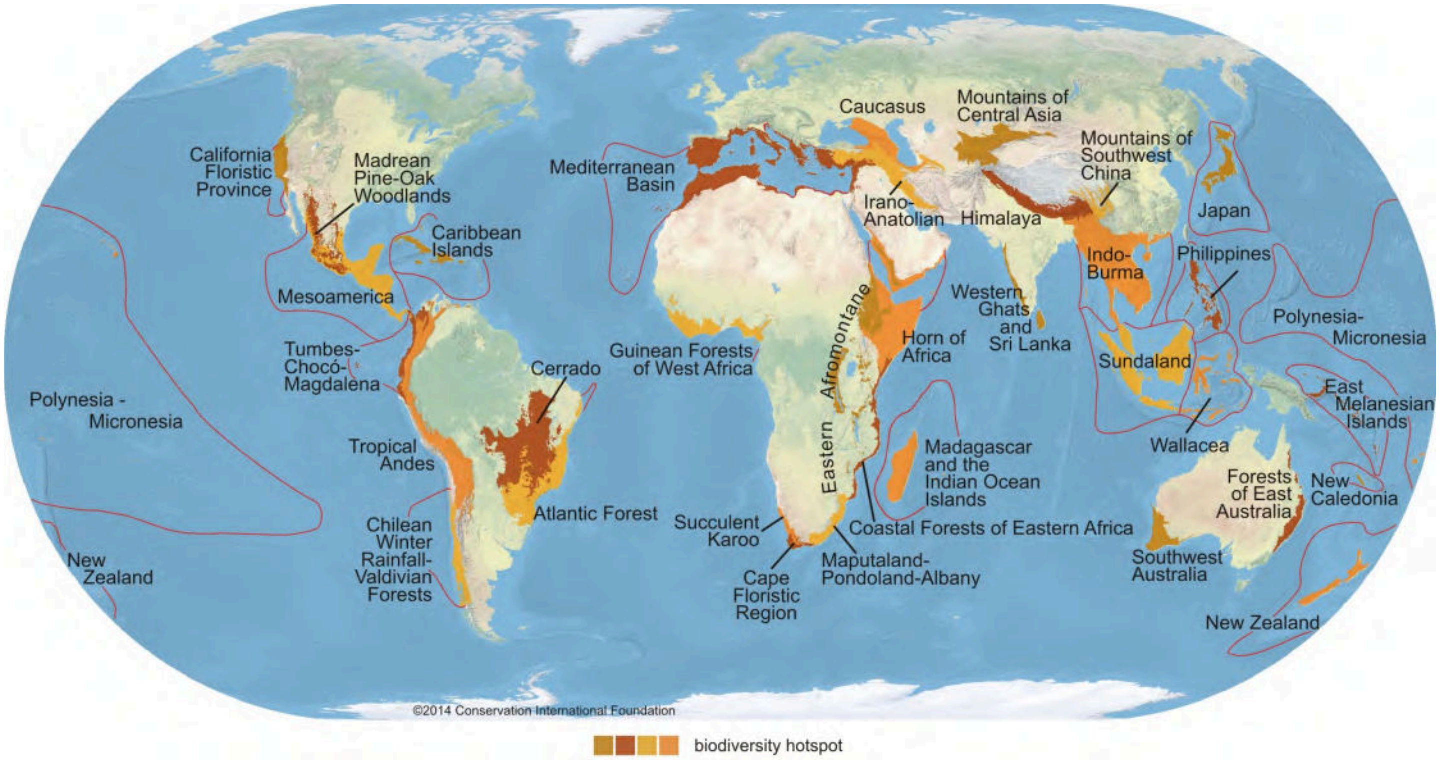
1) Develop a methodology for quantifying the biodiversity finance gap at the national level.
2) Improving cost-effectiveness through mainstreaming of biodiversity into national development & sectoral planning
3) Developing comprehensive national resource mobilizing strategies.

- It helps in implementing the **National Biodiversity Action Plan (NBAP)** & making progress towards achieving the **National Biodiversity Targets (NBTs).**
- BIOFIN in India is led by the **Ministry of Environment, Forest and Climate Change (MoEFCC).**
- The initiative is **hosted by the National Biodiversity Authority (NBA),** working with four relevant **State Biodiversity Boards**, with technical assistance from **Wildlife Institute of India (WII)** and National Institute of Public Finance and Policy (NIPFP).

11.5. Biodiversity Hot Spots



- **Biodiversity hotspots** are regions with **high species richness** and a **high degree of endemism**.
- The British biologist **Norman Myers** coined the term "biodiversity hotspot" in 1988 as a biogeographic region characterized both by **exceptional levels of plant endemism** and by **serious levels of habitat loss**.
- **Conservation International (CI)** adopted Myers' hotspots, and in 1996, the organization made the decision to undertake a reassessment of the hotspots concept.
- According to CI, to qualify as a hotspot, a region must meet two strict criteria:

1) It must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics – which is to say that it must have a high percentage of plant life found nowhere else on the planet. A hotspot, in other words, is irreplaceable.

2) It has to have lost at least 70% of its original habitat. (It must have 30% or less of its original natural vegetation). In other words, it must be threatened.

- In 1999, CI identified 25 biodiversity hotspots in the book "Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".
- Around the world, 36 areas qualify as hotspots representing just **2.5% of the earth's land surface**.

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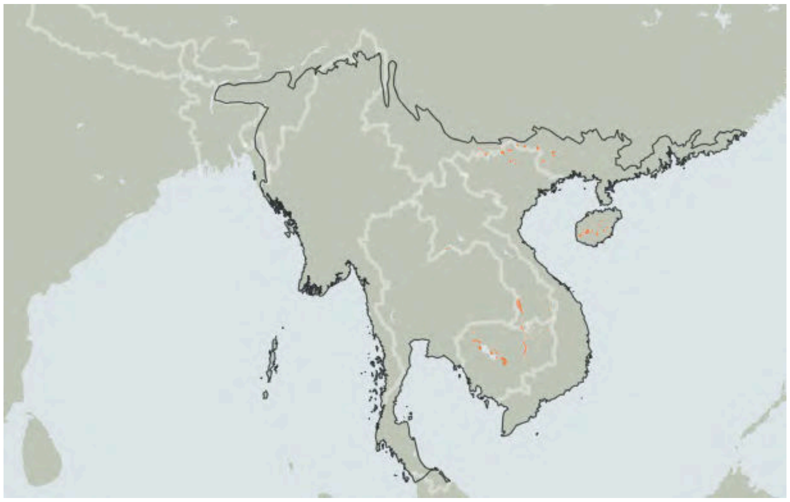
- They support **more than half of the world's plant species as endemics** and nearly 43% of bird, mammal, reptile, and amphibian species as endemics.
- In 2011, the Forests of the East Australia region was identified as the 35th biodiversity hotspot.
- In 2016, the North American Coastal Plain region was identified as the **36th biodiversity hotspot**.

11.5.1. Biodiversity Hotspots in India

1) **Himalaya:** Includes the **entire Indian Himalayan region** (and that falling in **Pakistan, Tibet, Nepal, Bhutan, China and Myanmar**).
2) **Indo-Burma:** Includes entire North-Eastern India, Andaman group of Islands and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China).



3) **Sundalands: Includes Nicobar group of Islands** (and Indonesia, Malaysia, Singapore, Brunei, Philippines).
4) **Western Ghats and Sri Lanka:** Includes **entire Western Ghats (and Sri Lanka)**.

Q. Consider the following statements: (2010)

1) Biodiversity hotspots are located only in tropical regions.
2) India has four biodiversity hotspots, i.e., Eastern Himalayas, Western Himalayas, Western Ghats and Andaman and the Nicobar Islands.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither I nor 2

Explanation:

- Eastern Himalayas was originally part of the **Indo-Burma Biodiversity Hotspot** and included Bhutan, North-Eastern India and southern, central and eastern Nepal.
- In 2004, a hotspot reappraisal classified the region as part of two hotspots: Indo-Burma and the newly distinguished Himalaya.
- The **Himalaya Hotspot** is home to important populations of numerous large birds and mammals, including vultures, tigers, elephants, rhinos and wild water buffalo.
- **Indo-Burma** holds remarkable endemism in **freshwater turtle species**, most of which are threatened with extinction due to over-harvesting and extensive habitat loss.

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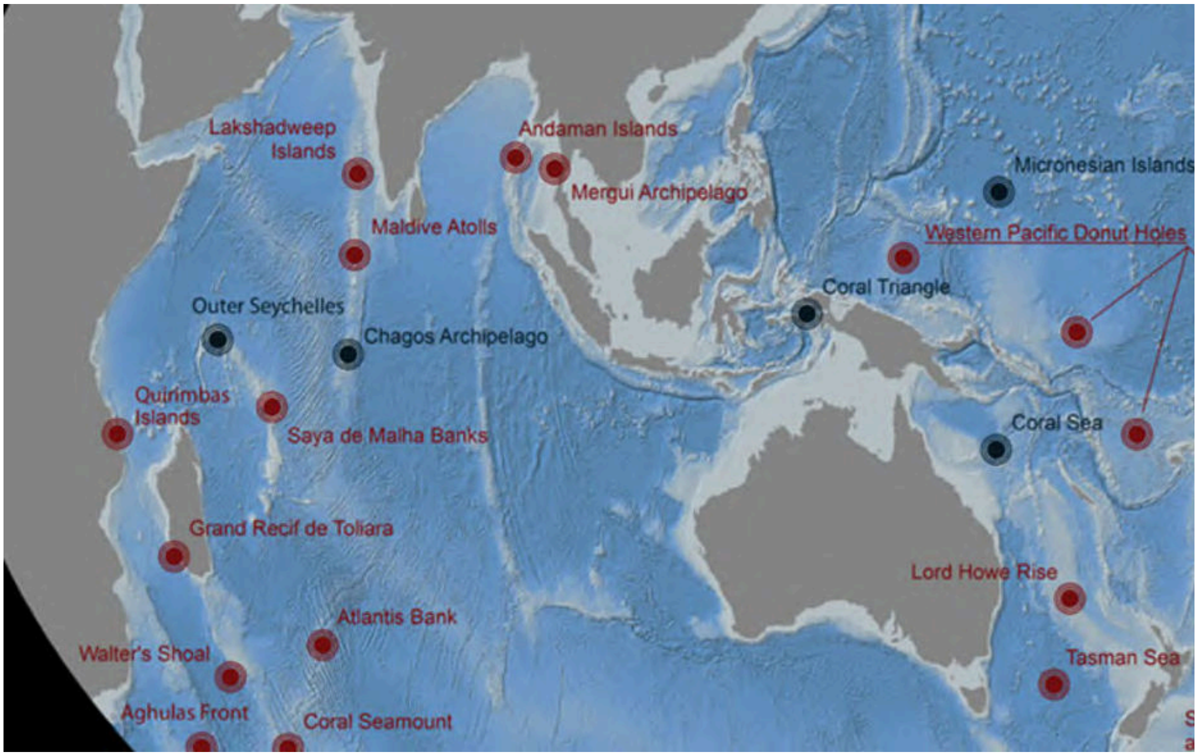
- The spectacular flora and fauna of the **Sundaland Hotspot** are succumbing to the explosive growth of **industrial forestry** in these islands and to the international animal trade that claims tigers, monkeys, etc.
- Faced with tremendous population pressure, the forests of the **Western Ghats and Sri Lanka** have been dramatically impacted by the demands for timber and agricultural land.
- The region also houses important populations of **Asian Elephants, Indian Tigers, the Lion-tailed Macaque, Niligiri tahr, Indian Giant squirrel**, etc.

Answer: d) neither

11.5.2. Hope Spots

- Hope Spot Network is a joint initiative of **Mission Blue** & **IUCN**.
- A hope spot is an **area of an ocean** that needs special protection because of its **wildlife & significant underwater habitats.**
- They are chosen for their contributions to biodiversity, the carbon sink, and important habitat.
- They can be **Marine Protected Area's (MPA – defined by IUCN)** that need attention or any new sites.



Hope Spot Sites from India

- **Lakshadweep Islands**
- **Andaman Nicobar Islands**

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12. Wildlife Conservation – Part I

- Conservation in the general sense means judicious use of biotic and abiotic resources. It involves the prevention of wasteful and/or harmful utilization of resources.
- Wildlife conservation refers to the practice of protecting wild species and their **habitats** (forests) in order to keep the natural ecosystems healthy.
- Major threats to wildlife conservation include habitat destruction, degradation, fragmentation, overexploitation (wildlife trade), poaching, pollution, and climate change.
- To address these issues, there have been both national and international governmental efforts to preserve Earth's wildlife.

12.1. Regulating Trade in Wildlife

12.1.1. Convention on International Trade in Endangered Species of Wild Fauna & Flora (CITES)

- CITES is also known as the **Washington Convention**.
- It is an international agreement (**multilateral treaty**) between governments.
- It was drafted as a result of a resolution adopted by members of IUCN in 1963.
- It entered into force in 1975.
- Its aim is to ensure that **international trade in specimens of wild animals and plants does not threaten their survival**.

Parties to CITES

- States that have agreed to be bound by the convention are known as Parties.
- **CITES is legally binding on the Parties**. **However, it does not take the place of national laws**.
- **It only provides a framework** to be respected by each Party. The parties need to **adopt their own domestic legislation** to ensure that CITES is implemented at the national level.

Q. With reference to the IUCN and the CITES, which of the following statements is/are correct?

1) IUCN is an organ of the United Nations and CITES is an international agreement between governments.
2) IUCN runs thousands of field projects around the world to better manage natural environments.
3) CITES is legally binding on the States that have joined it, but this convention does not take the place of national laws.

Select the correct using the code given below.

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- **IUCN is an NGO**. CITES is an international agreement between governments (multilateral treaty).

Answer: b) 2 and 3 only

Conference of Parties to CITES (CoP)

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- The CITES CoP is where governments around the world convene **every two to three years** to review and make decisions on the regulation of trade in endangered species.
- Representatives of the Parties to CITES, NGOs, and others attend CoP meetings.
- However, only CITES Parties can vote on decisions at the CoP.

The CoP will decide on:

- Proposals to **list, remove or change the listing of species on the CITES appendices**.
- Policy and implementation measures to improve the effectiveness of the convention.

Functioning of CITES

- CITES works by subjecting **international trade in specimens** of **selected species** to certain controls.
- All import and export of species covered by CITES have to be authorized through a **licensing system**.
- Each Party designates
  - ✓ one or more **Management Authorities** in charge of administering the licensing system and
  - ✓ one or more **Scientific Authorities** to advise them on the effects of trade on the status of the species.
- Management Authority in India: **Director of Wildlife Preservation**, **MoEFCC**.
- Other Management Authorities competent to grant permits: **Wildlife Crime Control Bureau (WCCB)**.
- Scientific Authorities: **Zoological Survey of India, Botanical Survey of India, Wildlife Institute of India**, etc.

The protection offered to species by CITES

- CITES accords varying degrees of protection to more than 35,000 species of animals and plants.
- The species covered by CITES are listed in **three Appendices** according to the degree of protection they need.

Appendices I

- Appendix I includes **species threatened with extinction**.
- **Trade in specimens** of these species is **permitted only in exceptional circumstances**.

Appendix II

- Appendix II includes species **not necessarily threatened with extinction**, **but in which trade must be controlled in order to avoid utilization incompatible with their survival**.
- At each regular meeting of the CoP, Parties submit proposals to amend these two Appendices.
- Those amendment proposals are discussed and then submitted to a vote.

Appendix III

- This Appendix contains species that are **protected in at least one country**, **which has asked other CITES Parties for assistance in controlling the trade**.

12.1.2. The 18th Conference of the Parties to CITES (CoP18)

- CoP18 has was held in 2019 in **Geneva, Switzerland**.
- The last CITES CoP (CoP17) was held in 2016 in Johannesburg, South Africa.

Major developments in CITES CoP18

- Zambia floated a proposal to downlist its elephants to **Appendix II of CITES**, which in effect would have meant resuming the **sale of its ivory stockpile**.
- Governments **rejected** the proposal to resume international sales of ivory stockpiles.
- **Elephants from the wild will no longer be shipped to zoos and circuses around the globe**.

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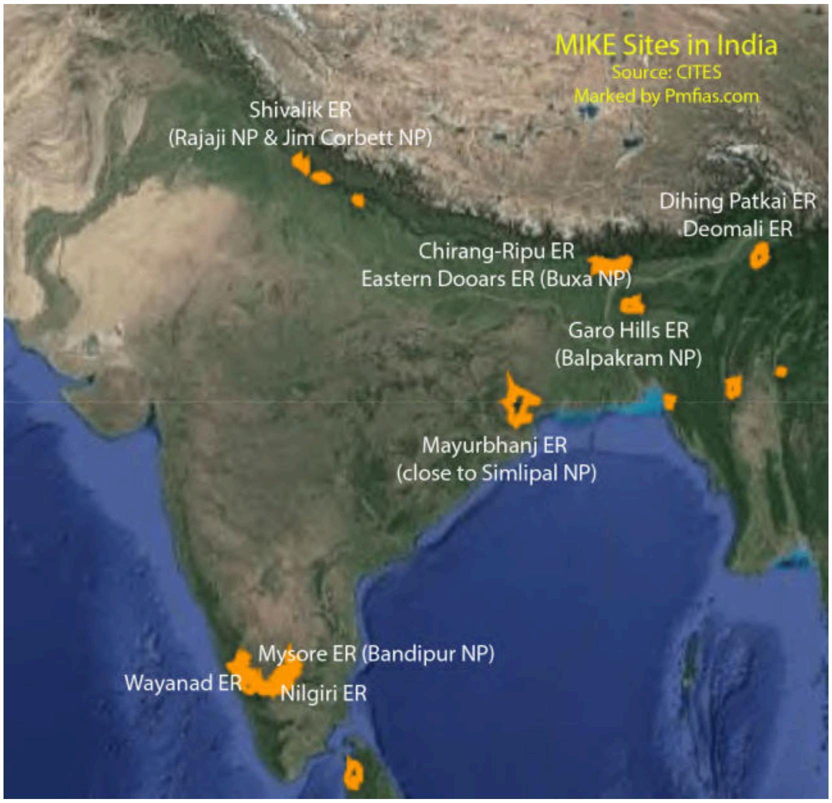
- A resolution calling for **Japan** and the **EU** to close their **legal domestic ivory markets** was **not** adopted at the CoP18. (At least 20,000 elephants are being illegally killed each year in Africa for their ivory.)

India sought to boost the protection status of 5 species at CITES CoP18

- India has submitted proposals to the CITES regarding changes to the listing of various wildlife species.
- The proposals submitted are regarding changes in the listing of the **smooth-coated otter, small-clawed otter, Indian star tortoise, Tokay gecko (LC), wedgefish (CR)** and **Indian rosewood (VU)**.
- The country seeks to boost the protection of all the five animal species as they are facing a **high risk of international trade**. India wants them to be moved from **CITES Appendix II** to **Appendix I**.
- India has also supported proposals to boost the protection status for **tarantulas (large hairy spiders)**.
- For the **Indian rosewood**, the proposal is to remove the species from CITES. The species is currently part of **Appendix II** of CITES.
- 27/08/2019: **Star tortoise (VU), Asian small-clawed (VU)** and **smooth-coated otters (VU)** were included in **Appendix I**.
- A **complete international ban will be enforced on their trade as part of efforts** to boost numbers.

12.1.3. Monitoring the Illegal Killing of Elephants (MIKE)



- The MIKE Programme was established by a **CITES Resolution adopted at the CoP10 in 1997**.
- MIKE is an **international collaboration** that measures the levels, trends and causes of elephant mortality.

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- MIKE's information base is used to support international decision-making related to the **conservation of elephants in Asia and Africa**.
- The information and analyses are also presented at annual **CITES** meetings and meetings of the CoPs.
- One of the core mandates given to the MIKE Programme is to build capacity in **elephant range States**.
- There are currently 28 sites participating in the MIKE programme in Asia, distributed across **13 countries**.
- **India has 10 MIKE sites**, followed by two sites each in **Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar** and **Thailand**, and one site each in **Bangladesh, Bhutan, China, Nepal, Sri Lanka** and **Vietnam**.
- In 2017, **IUCN** was engaged by **CITES** to implement the **MIKE Asia programme** in two sub-regions:
  - ✓ **South Asia – Bangladesh, Bhutan, India, Nepal and Sri Lanka**
  - ✓ **Southeast Asia – Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Thailand & Vietnam**.
- MIKE is entirely dependent on **donor support**. The **European Union** has been the most important donor for the MIKE programme in Africa since 2001 and in Asia since 2017.

12.1.4. The Wildlife Trade Monitoring Network (TRAFFIC)

- TRAFFIC is an **NGO (CITES, on the other hand, is a multilateral treaty)** working globally on trade in wild animals and plants in the context of both **biodiversity conservation and sustainable development**.
- TRAFFIC is a **joint programme** of **the World Wide Fund for Nature (WWF)** and **IUCN**.
- Traffic is complementary to CITES.
- The programme was founded in 1976, with headquarters now located in Cambridge, United Kingdom.
- TRAFFIC's mission is to ensure that **trade in wild plants and animals is not a threat to the conservation of nature**.
- It investigates and analyses wildlife trade trends, patterns, impacts and drivers to provide the leading **knowledge base on trade in wild animals and plants**.

Q. Consider the following statements in respect of TRAFFIC: (2017)

1. TRAFFIC is a bureau under United Nations Environment Programme (UNEP).
2. The mission of TRAFFIC is to ensure that trade in wild plants and animals is not a threat to the conservation of nature.

Which of the above statements is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: b)

12.1.5. Coalition Against Wildlife Trafficking (CAWT)

- It is a coalition that promises to collaborate in the fight **against illegal trade in wildlife & wildlife parts.**
- It is a **US-led** Coalition Against Wildlife Trafficking (CAWT) launched in 2005,
- **India is a member.**
- CAWT's initial partners include:
  - ✓ **Conservation International**
  - ✓ **Save the Tiger Fund**
  - ✓ **Smithsonian Institution**
  - ✓ **TRAFFIC International**

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12.1.6. Policies and Laws Concerning CITES in India

- International trade in all wild fauna and flora is regulated jointly through the provisions of the
  - ✓ **Wildlife (Protection) Act 1972**,
  - ✓ **Foreign Trade (Development Regulation) Act 1992,**
  - ✓ **Foreign Trade Policy of Government of India and**
  - ✓ **Customs Act, 1962.**

Wildlife (Protection) Act, 1972

- **Harming endangered species** listed in **Schedule I** of the Act is **prohibited throughout India**.
- **Hunting species** that require **special protection (Schedule II)**, **big game (Schedule III)**, **and small game (Schedule IV)** is **regulated through licensing**.
- A few species classified as **vermin (Schedule V)** may be **hunted without restrictions**.
- The act **prohibits the trade in specified plants (Schedule VI)** from an area specified by notification by GOI.
- The **Schedule VI of the Act** lists **all the six plants of Indian origin included in CITES appendices**.
- **Trade in Scheduled animals (Schedule I and Part II of Schedule II) are prohibited** under the act.
- Similarly, the act **disallows trade in all kinds of imported ivory**, including that of the **African elephant**.
- The act has been amended in 2006, leading to the establishment of the **National Tiger Conservation Authority** and the **Wild Life Crime Control Bureau (WCCB)** with **statutory backing**.

Foreign Trade (Development and Regulation) Act 1992

- No export or import should be made except in accordance with the provisions of this act.
- The act empowers GOI to order or make provisions for prohibiting/regulating the import or export of any class of goods, which includes **wildlife specimen** and their products.

Foreign Trade Policy (2009-2014)

- Foreign Trade Policy announced periodically by the **Ministry of Commerce** contains information regarding the wild-life and wildlife products which are prohibited/permitted for the purpose of import or export.
- The policy is decided in consultation with the **Management Authority for CITES** in India as far as matter relating to wild fauna and flora are concerned and is enforced through the **Customs Act, 1962**.

EXIM Policy

- Export/import of wild animals and plants, their parts and products is **allowed** for the purpose of **research** and **exchange between Zoos**, subject to licensing by the **Director-General of Foreign Trade** (DGFT).
- The current policy does not permit the commercial import of African ivory in view of the ban imposed by CITES.
- Import of other derivatives of wildlife is **restricted** and can be made only with the prior permission of DGFT.
- The import of wild animals as **pets** is also subject to the provisions of CITES.

Enforcement: Wildlife Crime Control Bureau (WCCB)

- Considering the seriousness of Wildlife Crime and the illegal trade of wildlife parts and products, the Wildlife Crime Control Bureau was created in 2007 under the provisions of the **Wildlife Protection Act 1972**.
- **Wildlife Crime Control Bureau** is the **designated nodal agency for CITES related enforcement**.
- WCCB is a **statutory** multi-disciplinary body under the **MoEFCC**.
- The Bureau has its
  - ✓ five regional offices at Delhi (headquarters), Kolkata, Mumbai, Chennai and Jabalpur; and
  - ✓ five border units at Ramanathapuram, Gorakhpur, Motihari, Nathula and Moreh.

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- Under the **Wild Life (Protection) Act, 1972**, WCCB is mandated to
  - ✓ collect and collate **intelligence related to organized wildlife crime**;
  - ✓ disseminate the same to State and other enforcement agencies so as to apprehend the criminals;
  - ✓ to establish a **centralized wildlife crime data bank**;
  - ✓ **coordinate** actions by various agencies in connection with the enforcement of the provisions of the act;
  - ✓ **assist international organizations & foreign authorities** to facilitate wildlife crime control;
  - ✓ capacity building of the wildlife crime enforcement agencies;
  - ✓ assist State Governments to **ensure success in prosecutions related to wildlife crimes**; and
  - ✓ **advise** the Government of India on issues relating to wildlife crimes.
- It also assists and advises the **Customs authorities** in inspection of the consignments of flora & fauna as per the provisions of Wild Life Protection Act, CITES and EXIM Policy governing such an item.

Operation 'Clean Art'

- **Operation Clean Art** was the first pan India operation to crackdown on the smuggling of **mongoose hair**.
- It was conceived by **Wildlife Crime Control Bureau (WCCB)** with the aim of ensuring that the **mongoose hairbrush trade** should be closed across the country.
- For about 150 kg of mongoose hair, at least 6,000 animals would have been killed.
- All **mongoose species** found in India are protected under **Schedule II of WPA**.
- The species are also covered under the **CITES Appendix 1** with a **complete ban on its commercial trade**.

'Not all animals migrate by choice' campaign

- 'Not all animals migrate by choice' campaign is launched to **raise awareness on illegal wildlife trade**.
- The campaign was launched by the **Wildlife Crime Control Bureau of India** and **UN Environment**.
- The campaign aims at garnering public support for the protection and conservation of wildlife, prevention of smuggling and reduction in demand for wildlife products.
- The campaign also complements worldwide action on illegal trade in wildlife through **UN Environment's global campaign, Wild for Life**.
- Phase I of the campaign featured **Tiger (EN), Pangolin (EN), Star Tortoise (VU)** & **Tokay Gecko (LC)**.
- Phase II will see more threatened species and explore other routes of trafficking.

12.2. Convention on Migratory Species (CMS)

- The **Convention on Migratory Species (CMS)** or The **Convention on the Conservation of Migratory Species of Wild Animals (CMS)** is also known as **Bonn Convention** or **Global Wildlife conference**.
- It is an **international treaty**, concluded under the aegis of the United Nations Environment Programme.
- The convention was signed in 1979 in Bonn, Germany and entered into force in 1983.
- The CMS is the only global and UN-based intergovernmental organization established exclusively for the conservation of terrestrial, aquatic and avian **migratory species throughout their range**.

12.2.1. Classification of Species Under CMS

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- Under this convention, **migratory species** **threatened with extinction** are listed on **Appendix I (global conservation list for migratory species),** and Parties strive towards **strictly protecting these animals**.
- Migratory species that would **significantly benefit** from **international cooperation** are listed in Appendix II.

12.2.2. CMS COP13

- The **COP13** was organized in February 2020 in **Gandhinagar, Gujarat**.
- **India** has been designated the **President of the COP** for the next **three years**.
- Ten new species were added to CMS Appendices at COP13.
- **Seven species** were added to **Appendix I**, which provides the **strictest protection**.
- The **Asian Elephant (EN), Great Indian Bustard (CR)** & **Bengal Florican (CR)** are among the 7 species.
- **Oceanic White-tip Shark (CR), Jaguar (South America)**, **Little Bustard (highlands of Central Asia; Iberian Peninsula & Kashmir), Antipodean Albatross (Sea Bird).**
- CMS COP13 also adopted the **Gandhinagar Declaration**.
  - ✓ It underscores the **importance of migratory species** for a new global biodiversity strategy.
  - ✓ It calls for migratory species and the concept of '**ecological connectivity'** to be integrated and prioritized in the **post-2020 global biodiversity framework**.

12.2.3. Central Asian Mammals Initiative

- Through its **Central Asian Mammals Initiative**, the **Convention of Migratory Species** aims to conserve **15 migratory mammal species and their habitats** in **Central Asia (including Snow Leopard**, Saiga and **Bactrian Camel**).
- CAMI's working is approved for **2021-2026,** incorporating **IUCN Save Our Species' Central Asia initiative** as a possible **funding mechanism** for the conservation of key threatened migratory species.

List of animals Included in Central Mammals Initiative

- **Wild Yak, Yak**
- **Snow Leopard**
- Bukhara Deer
- **Asiatic Wild Ass / Khulan**
- **Cheetah**
- Mongolian Or White-Tailed Gazelle
- Goitered Or Black-Tailed Gazelle
- **Saiga Antelope**
- **Wild or Bactrian Camel**
- **Argali Sheep**
- Kiang
- **Chiru, Tibetan Antelope**
- Przewalski's Horse
- Tibetan Gazelle
- **Chinkara**
- **Leopard, Panther**

12.3. International Union for Conservation of Nature (IUCN)

- **IUCN** is an **international NGO** working in the field of **nature conservation** and **sustainable use of natural resources**.

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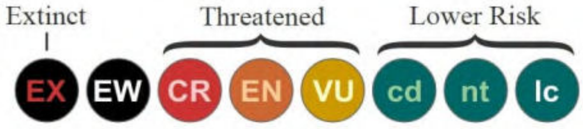
- It is involved in data gathering and analysis, research, field projects, advocacy, lobbying and education.
- The organization is best known for compiling and publishing the **IUCN Red List**, which assesses the **conservation status of species worldwide**.
- Its headquarters are in **Gland, Switzerland**.

12.3.1. IUCN Red List or Red Data List or Red Book

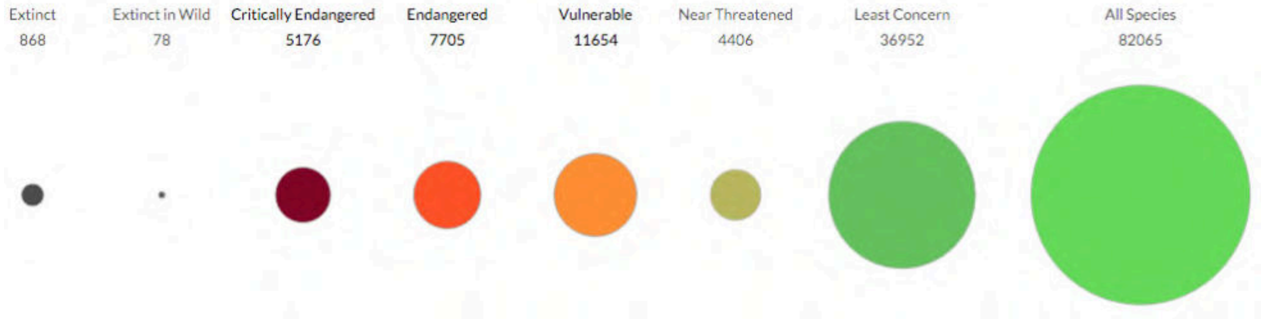
- The **IUCN Red List of Threatened Species**, founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species.
- When discussing the IUCN Red List, the official term **"threatened"** is a grouping of three categories: **Critically Endangered, Endangered,** and **Vulnerable**.



- The **pink pages** in this publication include the **critically endangered species**.
- As the status of the species changes, new pages are sent to the subscribers.
- **Green pages** are used for those species that were **formerly endangered but have now recovered to a point where they are no longer threatened**.
- With passing time, the number of pink pages continue to increase.

Species are classified by the IUCN Red List into 9 groups

- **Extinct (EX)** ➔ No known individuals remaining.
- **Extinct in the wild (EW)** ➔ Known only to survive in **captivity**, or as a naturalized population outside its historic range.
- **Critically endangered (CR)** ➔ Extremely high risk of extinction in the wild.
  - ✓ **reduction in population (greater than 90% over the last 10 years)**,
  - ✓ **population size (number less than 50 mature individuals — not applied very strictly though. Many CR species have populations greater than 50)**,
  - ✓ quantitative analysis showing the probability of extinction in wild in at least 50% in their 10 years, and
- **Endangered (EN)** ➔ High risk of extinction in the wild.
- **Vulnerable (VU)** ➔ High risk of endangerment in the wild.
- **Near threatened (NT)** ➔ Likely to become endangered in the near future.
- **Least concern (LC)** ➔ Lowest risk. Does not qualify for a more at-risk category. Widespread and abundant taxa are included in this category.
- **Data deficient (DD)** ➔ Not enough data to assess its risk of extinction.
- **Not evaluated (NE)** ➔ Has not yet been evaluated against the criteria.



Nine Groups in IUCN Red List

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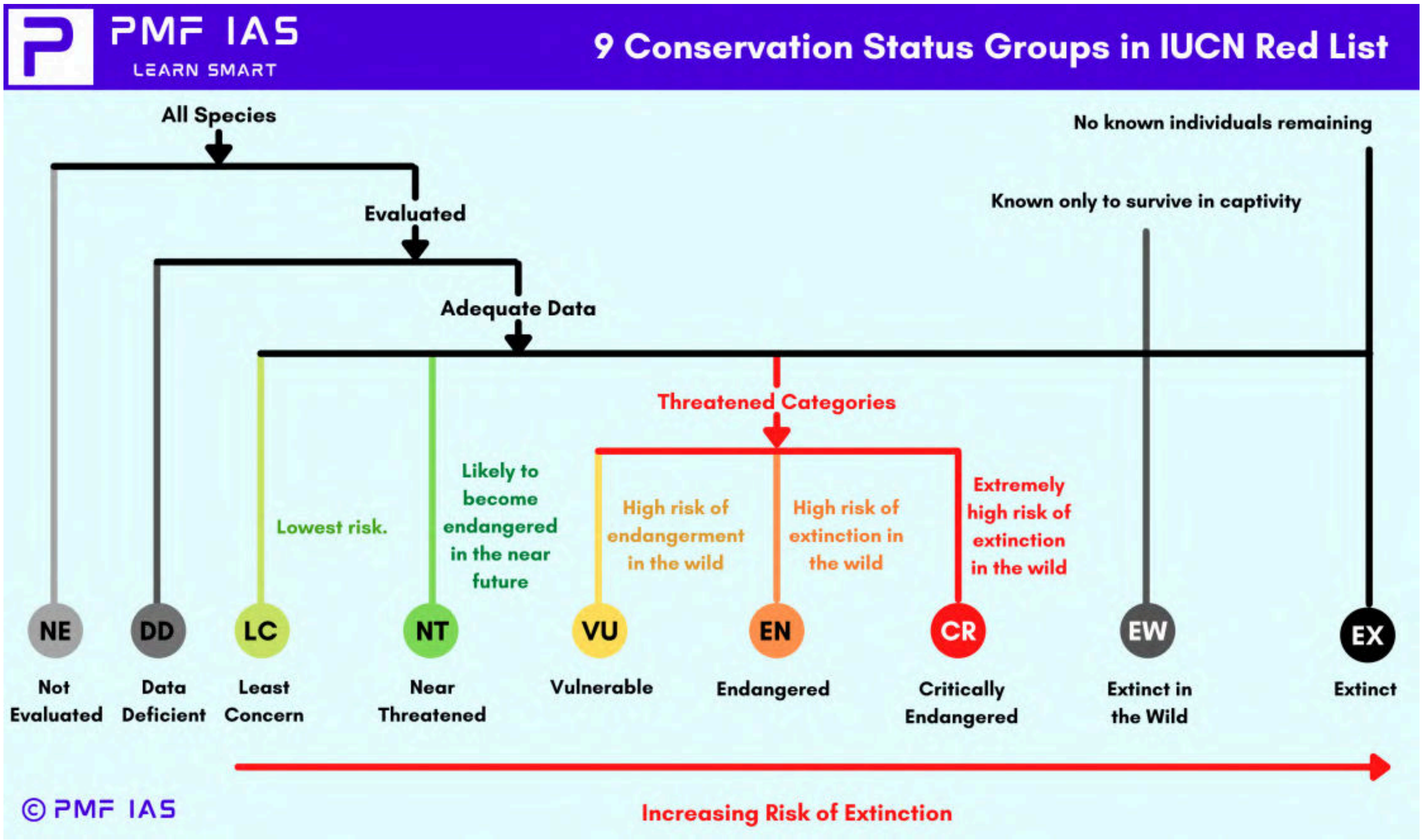

Q. The 'Red Data Books' published by the International Union for Conservation of Nature and Natural Resources (IUCN) contain lists of

1) Endemic plant and animal species present in the biodiversity hotspots.
2) Threatened plant and animal species.
3) Protected sites for conservation of nature & natural resources in various countries.

Which of the statement given above is/are correct?

a) 1 & 3
b) 2 only
c) 2 & 3
d) 3 only

Explanation:

- **IUCN is an NGO**. It publishes Red data book, which contains a list of **'Threatened species' (vulnerable, endangered and critically endangered)**.

Answer: b) 2 only

12.3.2. BirdLife International

- **BirdLife International** is the **world's largest nature conservation partnership**.
- Together they are 120 BirdLife Partners worldwide.
- BirdLife International strives to **conserve birds, their habitats and global biodiversity**, working with people towards sustainability in the use of natural resources.
- **BirdLife International** is the **official Red List authority for birds**, for the **IUCN**.
- It identifies the sites known/referred to as '**Important Bird and Biodiversity Areas**'.

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Q. With reference to 'Birdlife International' which of the following statements is/are correct?

1) It is a Global Partnership of Conservation Organizations.
2) The concept of 'biodiversity hotspots' originated from this organization.
3) It identifies the sites known/referred to as 'Important Bird and Biodiversity Areas'.

Select the correct answer using the code given below.

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- BirdLife International has nothing to do with the concept of "biodiversity hotspots".

Answer: c) 1 and 3 only

12.4. Tiger Conservation

- Since the early 1900s, the global population of tigers fell from around 100,000 to fewer than 4,000. Indian tiger numbers had hit an **all-time low of 1,411 in 2006.**
- **2006 Tiger Census** concluded that all the tigers from the Sariska reserve in Rajasthan had disappeared.
- Serious conservation efforts after 2006 reduced poaching and led to a steady increase in the tiger population.

12.4.1. Threats Faced by Tiger Population

- **Pressure on habitat**, **Habitat fragmentation** and **Habitat destruction**: Caused due to large-scale development projects such as dams, industry, mines, railway lines etc.
- **Invasive species:** Destroy the local producers. This has a **cascading effect on the food chain**. Tigers are the worst hit as they are at the end of the food chain. (Tigers represent an "**Umbrella Species**" that indicate the health of the ecosystem.)
- **Poaching and Wildlife Crime Control:** Poaching and wildlife crime continue to be major concerns, with poaching remaining a significant issue. Tigers are killed so their body parts can be used for **Traditional Chinese Medicine**.
- **Demand Elimination:** Eliminating demand for tiger products remains a significant hurdle.
- **Rebuilding Tiger Populations:** it remains a tough task, and countries except **India, Nepal** and **Russia** have struggled to rebuild their dwindling tiger population.

Canine Distemper Virus (CDV)

- **Canine Distemper Virus (CDV)** can be transmitted to wildlife from CDV-infected dogs living in and around wildlife sanctuaries.
- Canine distemper is a contagious and serious disease caused by a virus that attacks the respiratory, gastrointestinal and nervous systems of puppies and dogs.
- In 2018, over 20 lions from the Gir forest succumbed to the viral infection.

Prevention is better than cure

- Managing any disease in a wildlife population is extremely difficult.
- The main aim should be to vaccinate the free-ranging and domestic dogs in the area around national parks.
- NTCA has prepared guidelines to prevent the spillover of the disease to tigers and other wild animals.

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12.4.2. Measures Taken by the Government for Tiger Conservation

Legal

- Amendment of the Wild Life (Protection) Act, 1972 to Wild Life (Protection) Act, 2006 for providing enabling provisions towards constituting the **National Tiger Conservation Authority** and the **Tiger and Other Endangered Species Crime Control Bureau (Wildlife Crime Control Bureau).**
- Enhancement of punishment in cases of offence relating to a tiger reserve or its core area.

Administrative

- Strengthening of ant poaching activities, including special strategy for monsoon patrolling.
- State-level Steering Committees under the Chairmanship of Chief Ministers and establishment of **Tiger Conservation Foundation.**
- Creation of **Special Tiger Protection Force** (STPF) (Budget 2008)

Financial

- Financial and technical help is provided to the States under various Centrally Sponsored Schemes, viz. Project Tiger and **Integrated Development of Wildlife Habitats**.

3-pronged strategy to manage human/tiger negative interactions

- **Material and logistical support:** Funding support is provided through the ongoing Centrally Sponsored Scheme of **Project Tiger**.
- **Restricting habitat interventions:** Based on the carrying capacity of tigers in a tiger reserve, habitat interventions are restricted. The habitat interventions are kept limited to minimize man/animal conflict.
- **Standard Operating Procedure (SOPs):** The National Tiger Conservation Authority has issued SOPs to deal with man/animal conflict.

International Cooperation

- India has a bilateral understanding with Nepal on controlling trans-boundary illegal trade in wildlife.
- India has signed protocols on tiger conservation with Bangladesh and China.
- A sub-group on tiger/leopard conservation has been constituted for cooperation with Russia.
- A **Global Tiger Forum of Tiger Range Countries** has been created for addressing international issues related to tiger conservation.
- India is a party to **CITES**. CITES's landmark decision states that 'tigers should not be bred for trade in their parts and derivatives'.
  - ⇨ *There are eight subspecies of tiger. Among the eight, at present, five subspecies are present in the wild.*
  - ⇨ *They are Bengal, South China, Indochinese, Sumatran, and Siberian. Three subspecies of tiger —* ***Caspian, Bali***, and ***Javan — are extinct***.

12.4.3. Project Tiger (PT)

- Indian tiger population at the end of the 20th century was estimated at 20,000 to 40,000 individuals.
- The first country-wide tiger census conducted in 1972 estimated the population to comprise a little more than 1,800 individuals, an alarming reduction in tiger population.
- In 1973, Project Tiger was launched in **Jim Corbett National Park** of Uttarakhand, and various tiger reserves were created since then based on a **core-buffer** strategy.

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- India has **105 National Parks** and **more than 550 Wildlife Sanctuaries** of which **52** have been declared as Tiger reserves.
- Tiger reserves are governed by the **Project Tiger (1973)**.
- It is a **Centrally Sponsored Scheme** of the **Ministry of Environment and Forests.**
- It is administered by the **National Tiger Conservation Authority**.
- Aim: Protect tigers from extinction by ensuring a viable population in their natural habitats.
- Government has set up a **Tiger Protection Force** under Project Tiger to combat poachers.
- Project Tiger funds **relocation of villagers** to minimize human-tiger conflicts.

12.4.4. Core and Buffer Zones in Tiger Reserves

- The various tiger reserves were created in the country based on **'core-buffer' strategy**.
- Their protection status is the **same as wildlife sanctuaries**. But they are **monitored by NTCA (Project Tiger)**.

Core area

- The core areas are notified by the **State Government** in consultation with an Expert Committee (constituted for that purpose).
- **The core areas are freed of all human activities (but some tribes still continue to live in the core area (illegally). However, they do not possess any forest rights).**
- **Collection of minor forest produce, grazing, and other human disturbances are not allowed**.
- **It has the legal status of a national park or wildlife sanctuary**.
- The **Soligas of Karnataka's Chamarajnagar district** created history by becoming the **first tribal community living in the core area of a tiger reserve to get their forest rights recognized**.
- Soligas inhabit the peripheral forest areas of **Biligiri Rangana Hills** and Male Mahadeshwara.
- Their forest rights were recognized by the courts as they lived in the area in harmony with nature for hundreds of years, and their way of living was not causing any harm to the tiger population.
- In 1974, BR Hills (including Biligiri Ranganatha Swami Temple) area was declared as BRT Wildlife Sanctuary.
- The government evicted many Soligas from the forests and relocated them to nearby plains.
- In 2011, the sanctuary was declared a tiger reserve, and the forest officials restricted access and collection of non-timber forest produce.

Buffer areas

- **The buffer zone** is the area **peripheral to the critical tiger habitat or core area** providing **supplementary habitat** for dispersing tigers, besides offering scope for **co-existence of human activity (tribals)**.
- The limits of such areas are determined with the concerned **Gram Sabha** and an Expert Committee constituted for the purpose.
- Twin objectives of buffer zone include:
  - ✓ providing **habitat supplement** to spill overpopulation of wild animals from core area.
  - ✓ provide site-specific co-developmental inputs to villages for relieving their impact on core area.
- The **Forest Rights Act** passed by the Indian government in 2006 **recognizes the rights of some forest-dwelling communities** in buffer areas.
- Collection of minor forest produce and **grazing by tribals is allowed** in buffer zone on a **sustainable** basis.

12.4.5. Tiger Task Force

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- The implementation of Project Tiger over the years has highlighted the need for a statutory authority with the legal backing to ensure tiger conservation.
- On the basis of the recommendations of **National Board for Wild Life**, a Task Force was set up to look into the problems of tiger conservation in the country.
- The recommendations of the **Task Force** include strengthening of **Project Tiger** by giving it **statutory and administrative powers**.

National Board for Wild Life ==> Tiger Task Force ==> National Tiger Conservation Authority

12.4.6. National Tiger Conservation Authority (NTCA)

- The National Tiger Conservation Authority was established in December 2005 following a recommendation of the **Tiger Task Force**.
- The **Wild Life (Protection) Amendment Act**, 2006 provides for creating:
  1. **National Tiger Conservation Authority and**
  2. **Tiger and Other Endangered Species Crime Control Bureau (Wildlife Crime Control Bureau).**
- **National Tiger Conservation Authority administers Project Tiger**.
- **Administration of the tiger reserves will be in accordance with the guidelines of NTCA**.
- Tiger reserves in India are administered by field directors as mandated by NTCA.
- **No alteration in the boundaries** of a tiger reserve shall be made **except on a recommendation of the NTCA** and the **approval of the National Board for Wild Life**.
- **No State Government shall de-notify a tiger reserve**, except in public interest with the **approval of the NTCA** and the **approval of the National Board for Wild Life**.

NTCA members

- NTCA was set up under the **Chairmanship of the Minister for Environment and Forests**.
- The Authority will have
  a) **eight experts** having qualifications in wildlife conservation and welfare tribals,
  b) **3 MPs**,
  c) The **Inspector-General of Forests**, in charge of project Tiger, will be ex-officio Member Secretary
  d) Others

Functions of NTCA

- The Authority lays down standards, guidelines for **tiger conservation** in the Tiger Reserves, National Parks and Sanctuaries.
- The Tiger Conservation Authority would be required to prepare an **Annual Report**, which would be laid in the Parliament along with the Audit Report.
- **State level Steering Committees** will be set up in the Tiger States under the **Chairmanship of respective Chief Ministers**.
- This has been done with a view for ensuring coordination, monitoring and protection of tigers in the States.
- A provision has been made for the State Governments to prepare a **Tiger Conservation Plan.**
- Provision will be made for the States to establish a **Tiger Conservation Foundation** based on the good practices emanating from some tiger reserves.

Issues with Project Tiger

- The **Forest Rights Act** passed by the Indian government in 2006 recognizes the rights of some forest-dwelling communities in forest areas.

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- This has led to controversy over the implications of such recognition for tiger conservation.
- The project overlooks the role of abuse of power by authorities in the tiger crisis.

12.4.7. Tiger corridors in the country

- The **National Tiger Conservation Authority,** in collaboration with the **Wildlife Institute of India,** has published a document titled "**Connecting Tiger Populations for Long/term Conservation**".
- The document has mapped out **32 major corridors** across the country.

List of macro-landscape level tiger corridors

Landscape	Corridor	States/Country
Shivalik Hills & Gangetic Plains	• Rajaji-Corbett	Uttarakhand
	• Corbett-Dudhwa	Uttarakhand, Uttar Pradesh, Nepal
	• Dudhwa-Kishanpur-Katerniaghat	Uttar Pradesh, Nepal
Central India & Eastern Ghats	• Ranthambhore-Kuno-Madhav	Madhya Pradesh, Rajasthan
	• Bandhavgarh-Achanakmar	Madhya Pradesh, Chhattisgarh
	• Bandhavgarh-Sanjay Dubri-Guru Ghasidas	Madhya Pradesh
	• Guru Ghasidas-Palamau-Lawalong	Chhattisgarh & Jharkhand
	• Kanha-Achanakmar	Madhya Pradesh, Chhattisgarh
	• Kanha-Pench	Madhya Pradesh, Maharashtra
	• Pench-Satpura-Melghat	Madhya Pradesh, Maharashtra
	• Kanha-Navegaon Nagzira-Tadoba-Indravati	Madhya Pradesh, Maharashtra, Chhattisgarh, Andhra Pradesh
	• Indravati-Udanti Sitanadi-Sunabeda	Chhattisgarh, Odisha
	• Similipal-Satkosia	Odisha
	• Nagarjunasagar-Sri Venkateshwara National Park	Andhra Pradesh
Western Ghats	• Sahyadri-Radhanagari-Goa	Maharashtra, Goa
	• Dandeli Anshi-Shravathi Valley	Karnataka
	• Kudremukh-Bhadra	Karnataka
	• Nagarahole-Pusphagiri-Talakavery	Karnataka
	• Nagarahole-Bandipur-Mudumalai-Wayanad	Karnataka, Kerala, Tamil Nadu
	• Nagarahole-Mudumalai-Wayanad	Karnataka, Kerala, Tamil Nadu
	• Parambikulam-Eranikulam-Indira Gandhi	Kerala, Tamil Nadu
	• Kalakad Mundanthurai-Periyar	Kerala, Tamil Nadu
North East	• Kaziranga-Itanagar WLS	Assam, Arunachal Pradesh
	• Kaziranga-Karbi Anglong	Assam
	• Kaziranga-Nameri	Assam
	• Kaziranga-Orang	Assam
	• Kaziranga-Papum Pane	Assam
	• Manas-Buxa	Assam, West Bengal, Bhutan
	• Pakke-Nameri-Sonai Rupai-Manas	Arunachal Pradesh, Assam

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	• Dibru Saikhowa-D'Ering-Mehaong	Assam, Arunachal Pradesh
	• Kamlang-Kane-Tale Valley	Arunachal Pradesh
	• Buxa-Jaldapara	West Bengal

12.4.8. Tiger Census

- The process of estimating the number of tigers in a given area is called 'Tiger census'.
- Tiger Census Report is a **four-yearly report**.
- It is carried out by the **Wildlife Institute of India (WII — autonomous institution under the MoEF)** and the **National Tiger Conservation Authority (NTCA)**.
- The 2014 census had resulted in the **first-ever estimate of India's leopard population (11,000)**.

Estimation of Tiger Populations

- The most commonly used technique in Tiger Census in the past was '**Pugmark Census Technique'**.
- In this method, the imprints of the pugmark of the tiger were recorded and used as a basis for the identification of individuals (**and their sex**).
- Now it is largely used as one of the indices of tiger occurrence and relative abundance.
- Recent methods used to estimate the numbers of tigers are **camera trapping** and **DNA fingerprinting**.
- In camera trapping, the photograph of the tiger is taken, and individuals are **differentiated on the basis of the stripes on the body**.
- In the latest technique of **DNA fingerprinting**, tigers can be identified from their **scats (faeces)**.

2018 Census methodology

- The census methodology is based on Double sampling (based on ground-based surveys) and actual images captured on **camera-traps**.
- The double sampling method was introduced in 2006 as the **"pugmark" surveys** were found to be inaccurate.
- In the 2018 census, 83% of the big cats censused were **individually photographed** using camera traps.
- In Phases 1 & 2, ground-based surveys were carried out by Forest Department officials to collect signs of tiger presence like **scat and pugmarks**.
- In phase 3, the information was plotted on the forest map prepared with **remote-sensing** and **GIS (MSTrIPES)**.
- In the last phase, data were extrapolated to areas where cameras could not be deployed.

MSTrIPES – Technology in Wildlife Conservation

- MSTrIPES: **Monitoring system for Tigers – Intensive Protection and Ecological Status**.
- It was launched across Indian tiger reserves by **NTCA** and **WII** in 2010.
- MSTrIPES is a software-based monitoring system, designed to assist wildlife protection.
- The system consists of two components:
  1) field based protocols for patrolling, law enforcement, recording wildlife crimes & ecological monitoring,
  2) a customized GIS software for storage, retrieval, analysis, and reporting.
- Under MSTrIPES, **forest guards are expected to record their tracks** using a **GPS**, in addition to recording observations in site-specific data sheets.
- For 2018 census ground staff involved in the count used the **MSTrIPES** app.
- The app records the staff's path and helps upload **geo-tagged pictures into the central GIS database**.

Advantage of MSTrIPES

- GPS-based patrolling helps in mapping patrol routes and maintaining a spatial database of patrol tracks.
- Patrol maps help the management analyze trends and patterns to improve future protection efforts.

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- MSTrIPES will help identify shortcomings in patrolling efforts in real-time.
- It acts as proof of the presence and patrolling of forest guards in a particular area.

12.4.9. 2018 Tiger Census Report

- 2018 census is the **fourth cycle** of the tiger census based on **double sampling**.
- The first was conducted in 2006, second in 2010 and third in 2014.

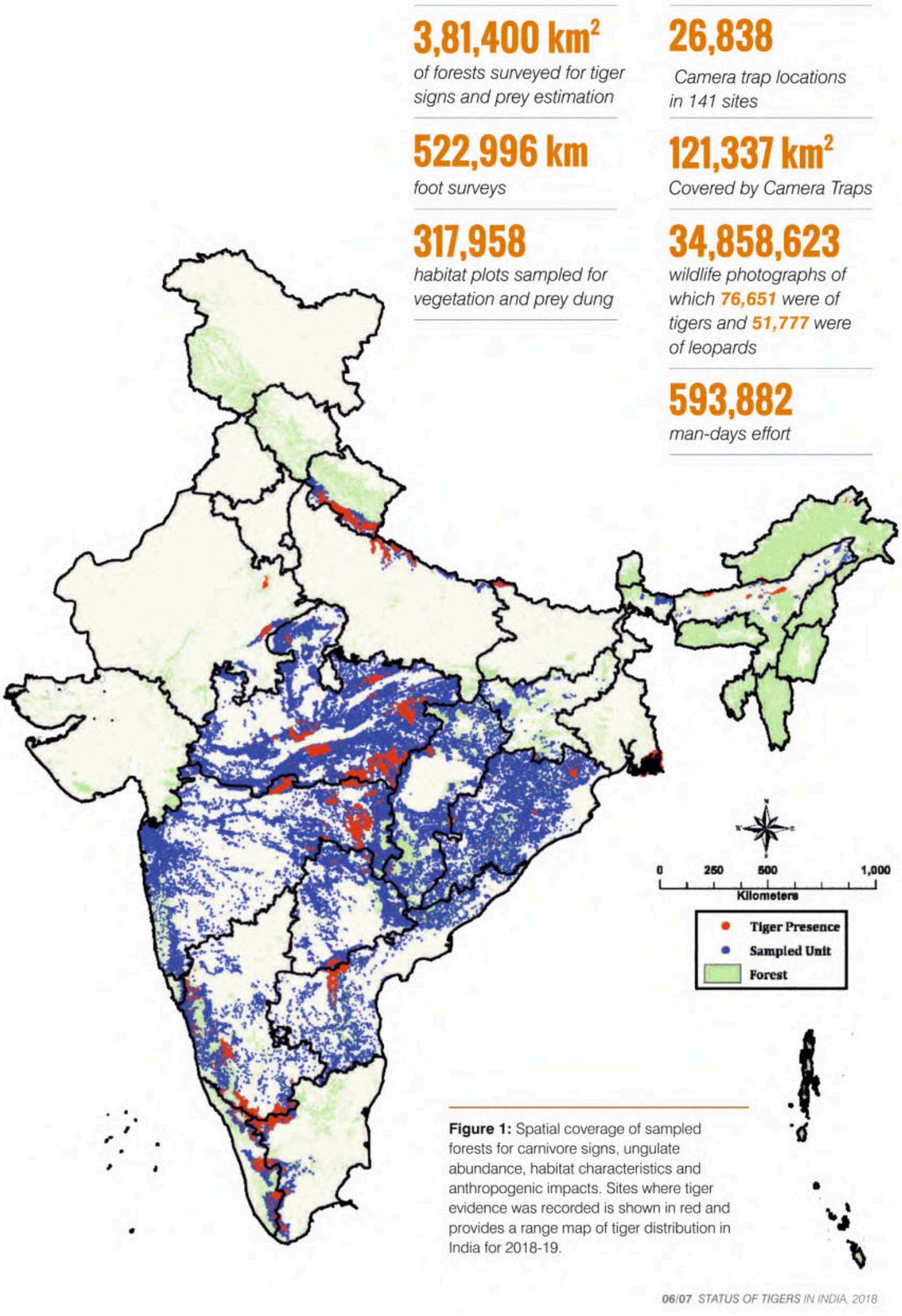

Figure 1: Spatial coverage of sampled forests for carnivore signs, ungulate abundance, habitat characteristics and anthropogenic impacts. Sites where tiger evidence was recorded is shown in red and provides a range map of tiger distribution in India for 2018-19.

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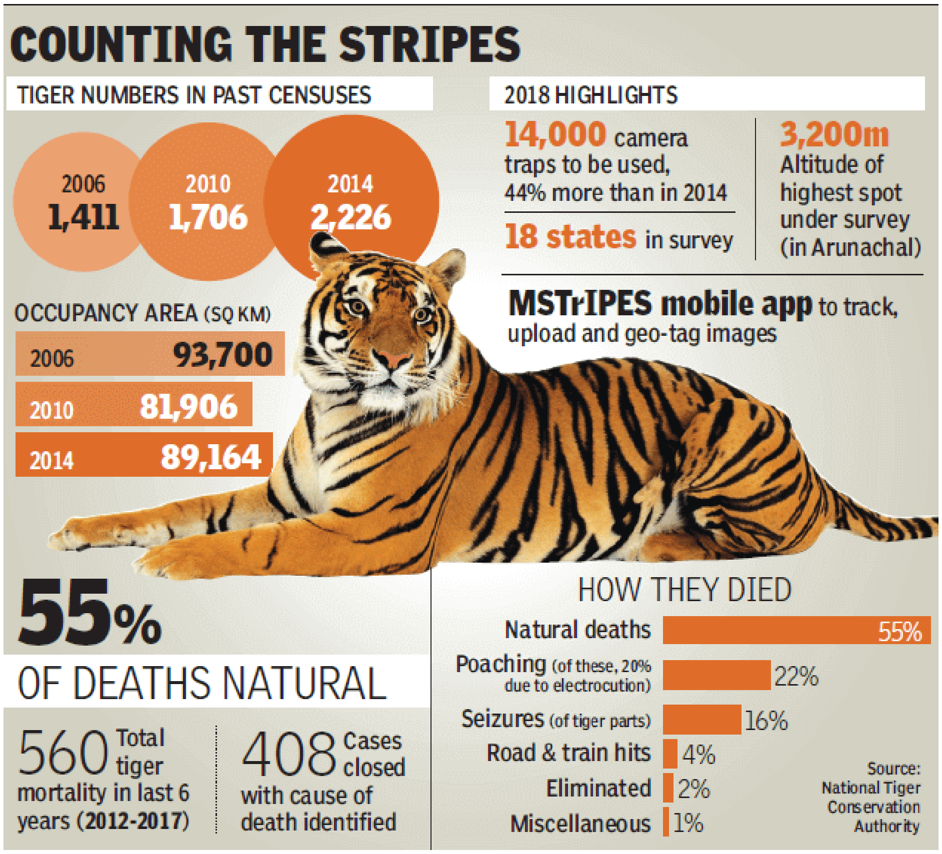

- India's five tiger landscapes are:
  1. **Shivalik Hills and Gangetic Plains,**
  2. **Central Indian Landscape and Eastern Ghats,**
  3. **Western Ghats, North-East Hills and**
  4. **Brahmaputra Plains, and**
  5. **the Sundarbans**.

Tiger population growth in India				
State	**2006**	**2010**	**2014**	**2018**
Shivalik Gangetic Plain				
Uttarakhand	**178**	**227**	**340**	**442**
Uttar Pradesh	109	118	117	173
Bihar	10	8	28	31
Central Indian Landscape and Eastern Ghats				
AP & Telangana	95	72	68	48 | 26
Chhattisgarh	26	26	46	19
Madhya Pradesh	**300**	**257**	**308**	**526**
Maharashtra	**103**	**169**	**190**	**312**
Odisha	45	32	28	28
Rajasthan	32	36	45	69
Jharkhand	-	10	3	5
Western Ghats				
Karnataka	**290**	**300**	**406**	**524**
Kerala	**46**	**71**	**136**	**190**

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Tamil Nadu	**76**	**163**	**229**	**264**
Goa	-	-	5	3
The Northeast				
Assam	**70**	**143**	**167**	**190**
Arunachal Pradesh	14	-	28	29
Mizoram	6	5	3	0
Northern West Bengal	10	-	3	0
Sundarbans	-	70	76	88
Total	**1,411**	**1,706**	**2,226**	**2967**

Important Observations from 2018 tiger census

1. **Madhya Pradesh (526) has the highest tiger population**.
2. **Karnataka (524) has the second-highest tiger population.**
3. **Uttarakhand (442) has the third-highest tiger population.**
4. Among the NE states, **Assam (190)** has the highest tiger population.
5. Tiger population **fell** in **Chhattisgarh** and **Mizoram**.
6. There is no change in the tiger population in **Odisha**.

Other Important observations from All India Tiger Estimation Report 2018

- India is home to almost **70% of the world tiger population**.
- The country has **2,967 tigers, a rise of 33%** over the figure found in the previous census of 2014 (2,226).

Region	Tiger Population (2014 Census)
1. Western Ghats	**776**
2. Central Indian Landscape and Eastern Ghats	**688**
3. Shivalik Gangetic Plain	485
India	**2226**
Region	**Tiger Population (2018 Census)**
1. Central Indian Landscape and Eastern Ghats	**1033**
2. Western Ghats	**981**
3. Shivalik Gangetic Plain	646
India	**2967**

- This is by far the biggest increase in terms of both numbers and percentage since the capture-mark-recapture method began in 2006.
- The number that year was 1,411; it rose by 295 (21%) to 1,706 in 2010, and by 520 (30%) to 2,226 in 2014.
- With this number, India has already fulfilled its resolve of **doubling tiger numbers**, made at the **St. Petersburg Declaration in 2010**, much before the target year of 2022.
  - ⇨ ***St. Petersburg Declaration**: 13 tiger home range countries agreed to **Global Tiger Recovery Program** that aimed to **double the global tiger population by 2022**.*
- The biggest increase has been in **Madhya Pradesh** — a massive 218 individuals (71%).
- In **Maharashtra**, the number has gone up from 190 to 312 (64%).
- Uttarakhand has gained over 100 tigers (340 to 442; 30%).
- **Pench Tiger Reserve** in Madhya Pradesh recorded the highest number of tigers.
- **Sathyamangalam Tiger Reserve** in Tamil Nadu registered the "maximum improvement" since 2014.

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- In **Buxa, Dampa** and **Palamau**, which are **tiger reserves, no trace of the animal was found**.
- The report does not contain numbers of other predators like leopards.

Forests with a potential of increasing tiger population

- **Sanjay and Guru Ghasidas forests** on the border of Madhya Pradesh and Chhattisgarh,
- **Kawal and Srirailam forests** in Andhra Pradesh and Telangana,
- **Simlipal and Satkosia tiger reserves** in Odisha,
- **Manas reserve** in Assam,
- **Buxa reserve** in West Bengal,
- **Palamau reserve** in Jharkhand and
- **Achanakmar and Indravati tiger** reserves in Chhattisgarh.

Measures that led to the increase in tiger population

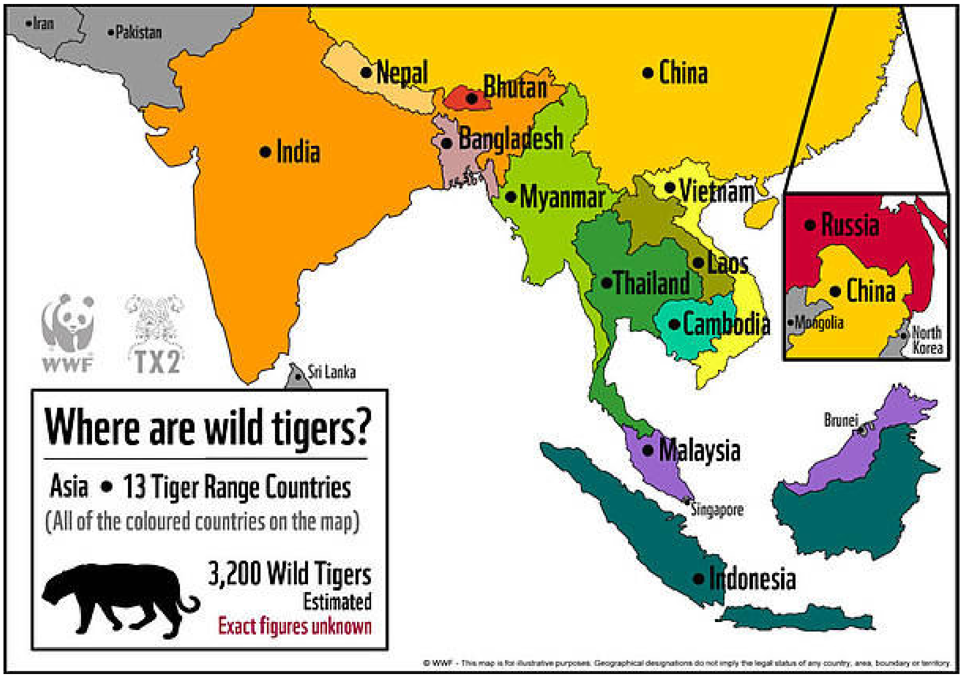
- Wireless communication systems and outstation patrol camps have been developed within the tiger reserves, due to which poaching has declined considerably.
- Many states deployed **special tiger forces** to combat organized poachers.
- Livestock grazing has been controlled to a great extent in the tiger reserves.
- Relocation of villages away from tiger reserves: ₹10 lakh was provided per family **that moved out of critical habitat**.
- From 28 in 2006, the number of tiger reserves went up to **52 in 2021**.

Concerns remain

- The fast-reducing forest cover still presents a threat to the wild cat.
- Under the current green cover, habitats reach **tiger-saturation** points far too early.

12.4.10. International Efforts Towards Tiger and Snow Leopard Conservation

The Global Tiger Initiative



- The **Global Tiger Initiative (GTI)** was launched in 2008 as a **global alliance** of governments, NGOs, civil society, and scientific communities, with the aim of working together to **save wild tigers from extinction**.

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- In 2013, the scope was broadened to include **Snow Leopards**.
- The **GTI's founding partners** included:
  - ✓ the **World Bank,**
  - ✓ the **Global Environment Facility (GEF),**
  - ✓ the **Smithsonian Institution** (**world's largest museum**, education, and research complex),
  - ✓ **Save the Tiger Fund** (from 1995 to 2011, it supported tiger conservation projects in Asia), and
  - ✓ **International Tiger Coalition** (representing more than 40 **non-government organizations**).
- The initiative is led by the **13 tiger range countries (TRCs)** — **Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Malaysia, Myanmar, Nepal, Russia, Thailand, and Vietnam**.

St. Petersburg Declaration and Global Tiger Recovery Program

- In 2010, leaders of the tiger range countries (TRCs) assembled at an **International Tiger Forum in St. Petersburg, Russia,** to adopt the **St. Petersburg Declaration on Tiger Conservation** and endorsed its implementation mechanism, called the **Global Tiger Recovery Program**.
- Their overarching goal was to **double the number of wild tigers** across their geographical area from about 3,200 to more than **7,000 by 2022**.
- **Successes include:**
  - ✓ India, Nepal and Russia have shown that tiger recovery is possible, despite challenges in poaching, funding and sustaining community livelihoods.
  - ✓ In India, Tiger Population in India increased from 1706 in 2010 to 2226 in 2015.
- **Failures:**
  - ✓ According to **World Wildlife Fund (WWF),** there are only around **3,900 tigers** remaining in the wild across the globe.
  - ✓ In **South-East Asia**, the tiger numbers kept dwindling.

International Consortium on Combating Wildlife Crime (ICCWC)

- It was established in **2010 in St. Petersburg** at Tiger Forum Meeting.
- It brings coordinated support to the **national wildlife law enforcement agencies** & to the sub-national and regional networks in **combating wildlife crimes.**
- It aims to **strengthen criminal justice systems** & provide **coordinated support** at the national, regional & international levels to combat wildlife & forest crime.
- **Partner agencies to ICCWC are:**
  1. CITES Secretariat
  2. INTERPOL
  3. United Nations Office on Drugs & Crime (UNODC)
  4. World Bank
  5. World Customs Organization (WCO)

Global Snow Leopard & Ecosystem Program (GSLESP)

- In 2013 **Global Tiger Initiative** scope was broadened to include **Snow Leopards**.
- Member countries adopted **Bishkek Declaration** that aims members to work together to **identify & secure at least 20 snow leopard landscapes** across the cat's range **by 2020** or, in short – "**Secure 20 by 2020**."
- **Members include:**
  1. Kyrgyzstan
  2. Afghanistan

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3. Kazakhstan
4. Mongolia
5. Pakistan
6. 13 Tiger Range Countries

- ⇨ **Gandhinagar Declaration:** adopted by all parties to CMS. It underscores the **importance of migratory species**. It calls for migratory species and the concept of '**ecological connectivity**'.
- ⇨ **St. Petersburg Declaration: Doubling the Tiger Population (T*2 Program)**. An initiative by **Global Tiger Recovery Program (GTRP)**
- ⇨ **Bishkek Declaration:** it wanted the members of the **Global Snow Leopard & Ecosystem Program (GSLESP)** to work together to **identify & secure at least 20 snow leopard landscapes** across the cat's range **by 2020** or, in short – "**Secure 20 by 2020**."

Snow Leopard Population Assessment in India

- Snow Leopard Population Assessment in India was launched during the 4th steering committee meeting of the **Global Snow Leopard and Ecosystem Protection Program (GSLEP).**
- This is the **1st time** that India will have a national level protocol to count snow leopard's population.
- It is a part of **Population Assessment of the World's Snow Leopard (PWAS)** launched by **GSLEP**.

TX2 Award and Tiger Conservation Excellence Award

- **TX2 Award** and **Tiger Conservation Excellence Award** are awarded to sites that are contributing towards achieving the **TX2 goal**.
- TX2 stands for "**Tigers times two**", signalling the **goal to double the population of wild tigers by 2022**.

TX2 Award

- The **TX2 Award** will go to one site that has achieved a **remarkable increase in its tiger population** since 2010.

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- **Pilibhit Tiger Reserve won the inaugural TX2 Award in 2020**.

Tiger Conservation Excellence Award

- **Conservation Excellence Award** recognizes one site that has **achieved excellence in at least 2/5 themes**:
  1. Tiger and prey population monitoring (tiger translocation/prey augmentation)
  2. Effective site management (**CA|TS assessments**)
  3. Enhanced Law Enforcement
  4. Community based conservation and Human-Wildlife conflict mitigation
  5. Habitat and prey management
- The **Transboundary Manas Conservation Area** (India-Bhutan border) has **received the Conservation Excellence Award for 2020**.
- Transboundary Manas Conservation Area comprises of
  1. The 500 sq km **Manas National Park in Assam** and
  2. The 1,057 sq km **Royal Manas National Park in Bhutan**.

Conservation Assured | Tiger Standards (CA|TS or CATS)

- CA|TS survey is the first & largest rapid **assessment of site-based tiger conservation across Asia**.
- Under the **accreditation system** of CA|TS, tiger conservation areas provide evidence to demonstrate that they meet a range of criteria for effective conservation management.
- CA|TS is a **partnership** between governments, NGOs & tiger conservation areas.
- It is the Set of minimum standards setting the benchmark for managing conservation sites.
- **WWF** is helping tiger range countries to implement CA|TS.

Global Tiger Forum

- Established in 1994, the Global Tiger Forum (GTF) has its headquarters in **New Delhi**.
- The General Assembly of GTF meets after **every three years**.
- It was set up to promote a worldwide campaign to save the tiger, its prey and its habitat.

12.5. Conservation of Snow Leopard

- Snow leopards (also known as **Ghost of the Mountains**) are both a **Keystone & Indicator Species** of the health of their high-altitude habitat.
- They inhabit **alpine & subalpine zones** at elevations from **3,000 to 4,500 m** in China, Mongolia and India.
- In India, their range encompasses a large part of the **western Himalayas,** including Ladakh, Himachal Pradesh and Uttarakhand.
- Sikkim & Arunachal Pradesh in the **eastern Himalayas** also host snow leopard populations.
- **Threats:** Human interference, competition with livestock, poaching, climate change, unregulated tourism, illegal trade, infrastructure development in the mountains, and excessive livestock grazing.
- The government has identified it as a **flagship species for the high-altitude Himalayan ecosystem**.
- Snow leopard is also included in **Species Recovery Programme**.
- Conservation Status
  - ✓ **IUCN Red List: Vulnerable**
  - ✓ **CITES – Appendix 1**
  - ✓ **Wildlife Protection Act 1972 – Schedule 1**

12.5.1. Project Snow Leopard

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- Project Snow Leopard was launched in **2009** with the objective to safeguard & conserve India's unique natural heritage of **high-altitude wildlife populations & their habitats**.
- For conservation, India has identified three large landscapes:
  1. **Hemis-Spiti across Ladakh and Himachal Pradesh**;
  2. **Nanda Devi – Gangotri in Uttarakhand**; and
  3. **Khangchendzonga – Tawang across Sikkim and Arunachal Pradesh**.
- In 2003, the **Convention on Migratory Species** included the snow leopard as a **Concerted Action Species** under its **Appendix I**.
- Similarly, in 2003, the CITES expanded the scope of the **CITES Tiger Enforcement Task Force** to include all Asian big cat species, including the snow leopard.

Why to conserve the high-altitude ecosystem?

- The high altitudes of India (> 3000 m) (including the Himalaya and Trans-Himalaya biogeographic zones) support highly endangered populations of species such as the **snow leopard**, two species of bears, **red panda**, mountain ungulates such as the **wild yak, chiru, Tibetan gazelle, Tibetan argali, Ladakh urial**, two species of **musk deer, the hangul**, three species of **goral, serow**, and **takin**, etc.
- High altitude lakes and bogs provide breeding grounds for a variety of avifauna including the **black-necked crane**, **bar-headed Geese**, etc.

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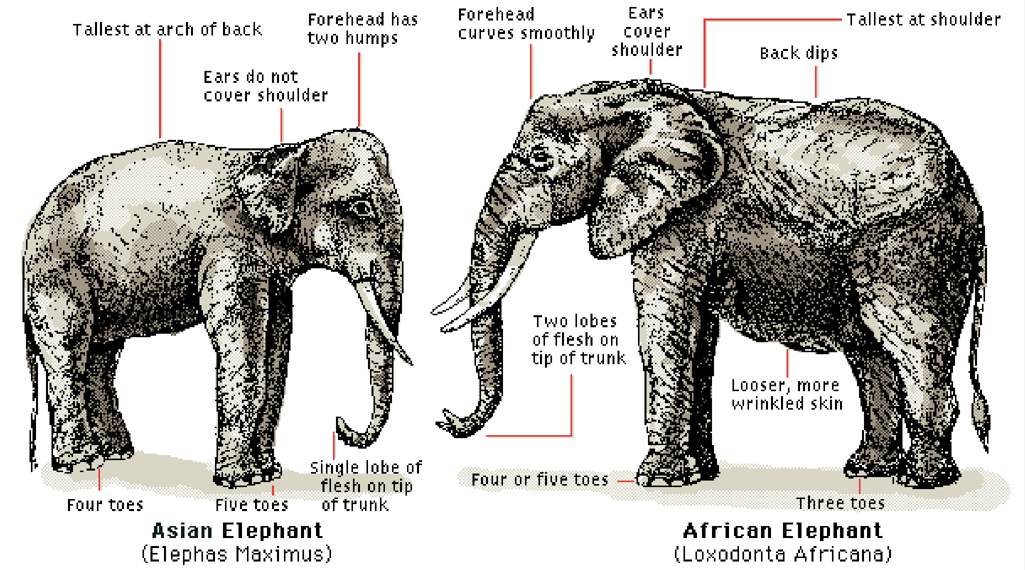
13. Wildlife Conservation – Part II

13.1. Elephant Conservation

13.1.1. Difference between African Elephant and Asian Elephant

- Elephants are **matriarchal**, meaning they live in **female-led groups**.

Asian Elephant	African Elephant
• Estimated 40,000 to 50,000. • **28,000** elephants in **India** with around **25%** of them in **Karnataka**.	• Estimated: 4,15,000
• Subspecies: Indian, Sumatran & Sri Lankan. • IUCN Red List: Endangered	• **Forest Elephant IUCN Red List:** Critically Endangered • **Savannah Elephant IUCN Red List:** Endangered
• **CITES:** Appendix-1 • Wildlife (Protection) Act, 1972: Schedule I.	• **CITES:** Appendix-1
• **Only some male Asian elephants have tusks**	• **Both male & female African elephants grow tusks.**
• They have only 1 finger-like feature on the end of their trunk	• They have 2 finger-like features at the tip of the trunk.



Asian elephants are smaller than their African cousins

13.1.2. Difference between African Forest Elephant and African Savanna Elephant

African Forest Elephant	African Savannah (Bush) Elephant
IUCN Red List: Critically Endangered	IUCN Red List: Endangered
Habitat: **Tropical forests** of Central Africa & in a range of habitats in West Africa.	Habitat: A variety of habitats in **sub-Saharan Africa,** including grasslands & deserts.

- **African Savannah (Bush) Elephant** is the **largest living terrestrial animal**.
- Poaching & land-use changes remain prominent challenges to African elephant populations.
- As **both males & females possess tusks**, the impact of ivory poaching is especially severe.

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- Earlier, African elephants were treated as a single species, listed as **Vulnerable**.
- This is the first time the two species have been assessed separately for the IUCN Red List.
- **African Forest Elephants** have a **longer pregnancy than any other mammal — almost 22 months**.
- This compound the problem of conservation. Hence, they are now added to the Critically Endangered list.

Q. With reference to Indian elephants, consider the following statements :

1. The leader of an elephant group is a female
2. The maximum gestation period can be 22 months.
3. An elephant can normally go on calving till the age of 40 years only.
4. Among the States in India, the highest elephant population is in Kerala.

Which of the statements given above is/ are correct?

a) 1 and 2 only
b) 2 and 4 only
c) 3 only
d) 1, 3 and 4 only

Explanation:

- Elephants are **matriarchal**
- **African Forest Elephants** have a **longer pregnancy than any other mammal — almost 22 months.**
- **Karnataka (6000+)** has the highest number of elephants in India, followed by Assam (5700+) and Kerala (5700+).
- Most females give birth for the first time between 14 and 15 years old in African elephants, and slightly later in Asian elephants.
- Fertility is constant between the ages of 16 and 40 and then declines slightly, though females over 60 can still give birth.

Answer: a) 1 & 2 only

13.1.3. Ecological Importance of Elephants

- Elephants are a **keystone species**. Their nomadic behaviour – the daily and seasonal migrations they make through their home ranges – is immensely important to the environment.
- **Landscape architects:** Elephants create clearings in the forest, preventing the overgrowth of certain plant species, allowing space for the regeneration of others, which in turn provide sustenance to other animals.
- **Seed dispersal:** Elephants release the seeds when they defecate in other places as they travel.
- **Nutrition:** Elephant dung provides nourishment to plants and acts as a breeding ground for insects.
- **Water providers:** In times of drought, they access the water by digging holes, which benefits other wildlife. Further, their large footprints collect water when it rains, benefitting smaller creatures.
- **Food chain: Apex predators like tigers** will sometimes hunt young elephants. Further, elephant carcasses provide food for other animals.
- **The umbrella effect:** By preserving a large area for elephants to roam freely, one provides a suitable **habitat for many other animal and plant species** of an ecosystem.

13.1.4. Project Elephant

- **The elephant** was declared as the **National Heritage Animal of India** in 2010
- While the tigers face the threat of extinction, the elephants face the threat of attrition (gradual reduction).

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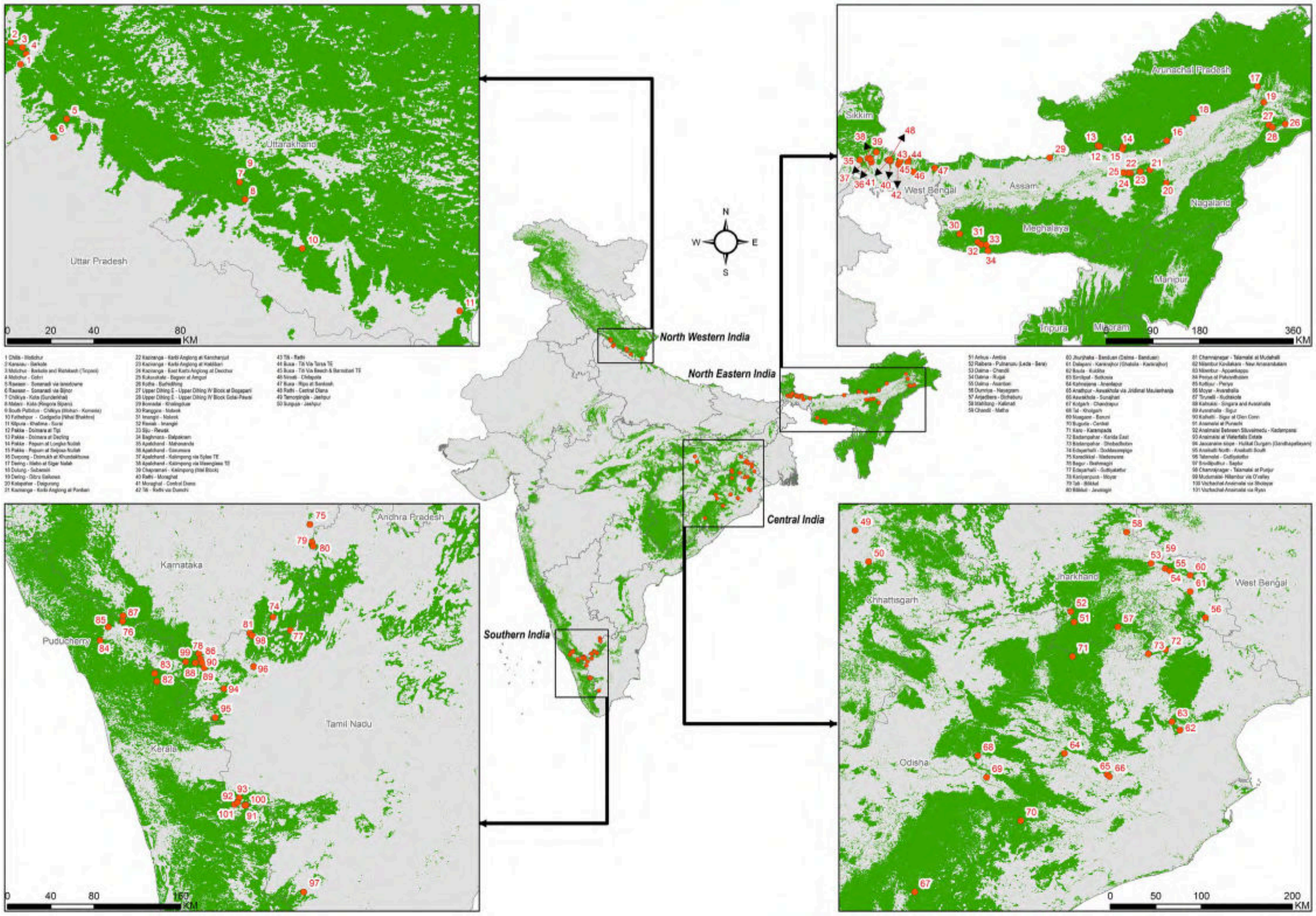
RIGHT OF PASSAGE
ELEPHANT CORRIDORS OF INDIA

Wildlife Trust of India | IFAW | ELEPHANT FAMILY Protecting Asian elephants and their habitat | IUCN National Committee of The Netherlands | WORLD LAND TRUST



1 Chilla - Motichur
2 Kansrau - Barkote
3 Motichur - Barkote and Rishikesh (Tinpani)
4 Motichur - Gohri
5 Rawasn - Sonanadi via lansdowne
6 Rawasn - Sonanadi via Bijnor
7 Chilkiya - Kota (Sunderkhal)
8 Malani - Kota (Ringora Bijrani)
9 South Patlidun - Chilkiya (Mohan - Kumeria)
10 Fathehpur - Gadgadia (Nihal Bhakhra)
11 Kilpura - Khatima - Surai
12 Pakke - Doimara at Tipi
13 Pakke - Doimara at Dezling
14 Pakke - Papum at Longka Nullah
15 Pakke - Papum at Seijosa Nullah
16 Durpong - Doimukh at Khundakhuwa
17 Dering - Mebo at Sigar Nalah
18 Dulung - Subansiri
19 Dering - Dibru Saikowa
20 Kalapahar - Daigurung
21 Kaziranga - Karbi Anglong at Panbari
22 Kaziranga - Karbi Anglong at Kanchanjuri
23 Kaziranga - Karbi Anglong at Haldibari
24 Kaziranga - East Karbi Anglong at Deochur
25 Kukurakata - Bagser at Amguri
26 Kotha - Burhidihing
27 Upper Dihing E - Upper Dihing W Block at Bogapani
28 Upper Dihing E - Upper Dihing W Block Golai-Pawai
29 Bornadai - Khalingduar
30 Ranggira - Nokrek
31 Imangiri - Nokrek
32 Rewak - Imangiri
33 Siju - Rewak
34 Baghmara - Balpakram
35 Apalchand - Mahananda
36 Apalchand - Gorumara
37 Apalchand - Kalimpong via Sylee TE
38 Apalchand - Kalimpong via Meenglass TE
39 Chapramari - Kalimpong (Mal Block)
40 Rethi - Moraghat
41 Moraghat - Central Diana
42 Titi - Rethi via Dumchi
43 Titi - Rethi
44 Buxa - Titi Via Torsa TE
45 Buxa - Titi Via Beech & Barnobari TE
46 Nimati - Chilapata
47 Buxa - Ripu at Sankosh
48 Rethi - Central Diana
49 Tamorpingla - Jashpur
50 Surguja - Jashpur

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51 Ankua - Ambia
52 Raibera - Pulnanuru (Leda - Bera)
53 Dalma - Chandil
54 Dalma - Rugai
55 Dalma - Asanbari
56 Dumriya - Nayagram
57 Anjadbera - Bichaburu
58 Mahilong - Kalimati
59 Chandil - Matha
60 Jhunjhaka - Banduan (Dalma - Banduan)
61 Dalapani - Kankrajhor (Ghatsila - Kankrajhor)
62 Baula - Kuldiha
63 Similipal - Satkosia
64 Kahneijena - Anantapur
65 Anathpur - Aswakhola via Jiridimal Maulanhanja
66 Aswakhola - Sunajhari
67 Kotgarh - Chandrapur
68 Tal - Kholgarh
69 Nuagaon - Baruni
70 Buguda - Central
71 Karo - Karampada
72 Badampahar - Karida East
73 Badampahar - Dhobadhobin
74 Edayarhalli - Doddasampige
75 Karadikkal - Madeswara
76 Begur - Brahmagiri
77 Edayarhalli - Guttiyalattur
78 Kaniyanpura - Moyar
79 Tali - Bilikkal
80 Bilikkal - Javalagiri
81 Chamrajnagar - Talamalai at Mudahalli
82 Nilambur Kovilakam - New Amarambalam
83 Nilambur - Appankappu
84 Periya at Pakranthalam
85 Kottiyur - Periya
86 Moyar - Avarahalla
87 Tirunelli - Kudrakote
88 Kalmalai - Singara and Avarahalla
89 Avarahalla - Sigur
90 Kalhatti - Sigur at Glen Corin
91 Anamalai at Punachi
92 Anaimalai Between Siluvaimedu - Kadamparai
93 Anaimalai at Waterfalls Estate
94 Jaccanaire slope - Hulikal Durgam (Gandhapallayam)
95 Anaikatti North - Anaikatti South
96 Talamalai - Guttiyalattur
97 Srivilliputhur - Saptur
98 Chamrajnagar - Talamalai at Punjur
99 Mudumalai- Nilambur via O'valley
100 Vazhachal-Anaimalai via Sholayar
101 Vazhachal-Anaimalai via Ryan

- The elephant numbers have not increased or decreased drastically, but there is increasing pressure on the elephant habitats.
- The **centrally sponsored scheme Project Elephant** was launched in 1992 to conserve the elephant population in their **natural habitats**.
- Objectives:
    - ✓ to assist states having populations of wild elephants and to ensure long term survival of identified viable populations of elephants in their **natural habitats**.
    - ✓ addressing **human-animal conflict**.
    - ✓ Developing scientific and planned management measures for the conservation of elephants.
    - ✓ Protecting the elephants from poachers, preventing illegal ivory trade and other unnatural causes of death.

13.1.5. Elephant Corridor

- Elephant corridors are **linear, narrow, natural habitat linkages** that allow elephants to move between secure habitats without being disturbed by humans.
- **Right of Passage**, a study published by the **Wildlife Trust of India (WTI)** in collaboration with **Project Elephant,** has identified 101 elephant corridors across India.
- The majority of these corridors are in **north-eastern India,** followed by **South India, central India,** northern West Bengal and north-western India.

Threats to Elephant Corridors

- **Habitat loss** happens due to fragmentation and destruction caused by developmental activities like construction of buildings, roads, railways, resorts, energized electric fencing, etc.
- Elephants need extensive grazing grounds, and most reserves cannot accommodate them. If protected areas are not large enough, elephants may search for food elsewhere.
- This often results in conflicts with humans due to elephants raiding or destroying crops.
- Human-Elephant Conflict is a profoundly serious issue in India today: over **400 humans are killed in encounters with elephants annually**, and crops and property worth millions of rupees are damaged.
- **Coal mining** and **iron ore mining** are the two "single biggest threats" to elephant corridors in **central and eastern India**.

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Mitigation

- Fusion of the corridors with nearby protected areas wherever feasible.
- Declaration of the corridors as Ecologically Sensitive Areas or conservation reserves to grant protection.
- Securing the corridors by sensitizing local communities and ensuring relocation voluntarily outside the conflict zones to safer areas.
- Preventing further fragmentation of the continuous forest habitat by encroachment from urban areas.
- Orissa, Jharkhand, and Chhattisgarh are mineral-rich states, but also have the highest number of elephant corridors in the country, which makes them known for elephant-human conflicts.
- There is also a serious poaching problem, as elephant ivory from the tusks is extremely valuable.

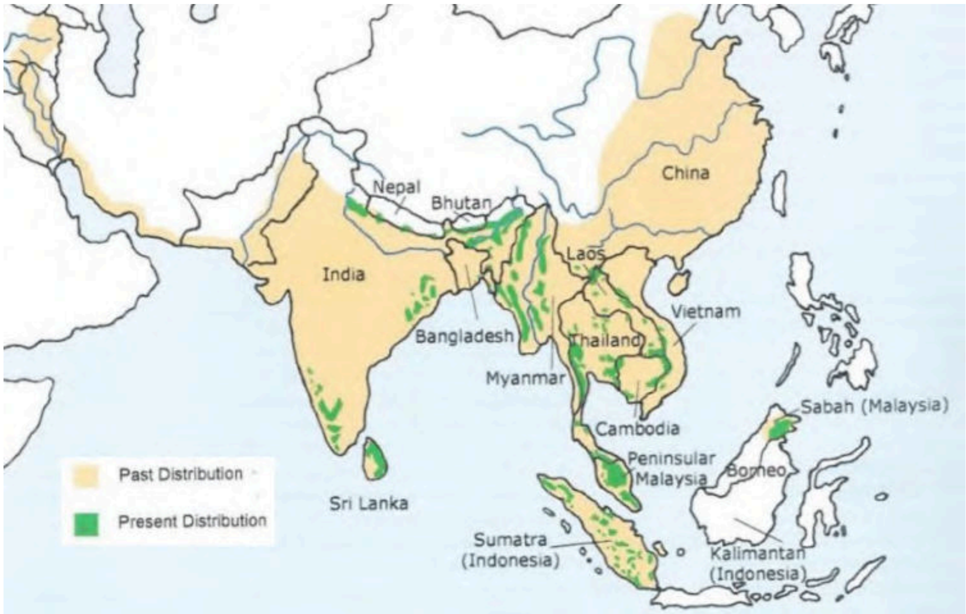
13.1.6. Haathi Mere Saathi

- **Haathi Mere Saathi** is a campaign launched by the **Ministry of Environment and Forest (MoEF)** in partnership with the **Wildlife Trust of India (WTI)**.
- The campaign was launched at the "Elephant- 8" Ministerial meeting held in Delhi in 2011.
- The **E-8 countries** comprise of **India, Botswana, the Republic of Congo, Indonesia, Kenya, Sri Lanka, Tanzania,** and **Thailand**.
- This public initiative was aimed at increasing awareness among people and developing friendship, companionship between people and elephants.

13.1.7. Asian Elephant Alliance

- It is a collation of **5 NGOs**
  - ✓ **Elephant Family**
  - ✓ **International Fund for Animal Welfare**
  - ✓ **IUCN**
  - ✓ **Wildlife Trust of India**
  - ✓ **World land Trust**
- It has come together to **secure 96 out of the 101 existing corridors** used by elephants across 12 States in India.

13.1.8. IUCN Asian Elephant Specialist Group (AsESG)



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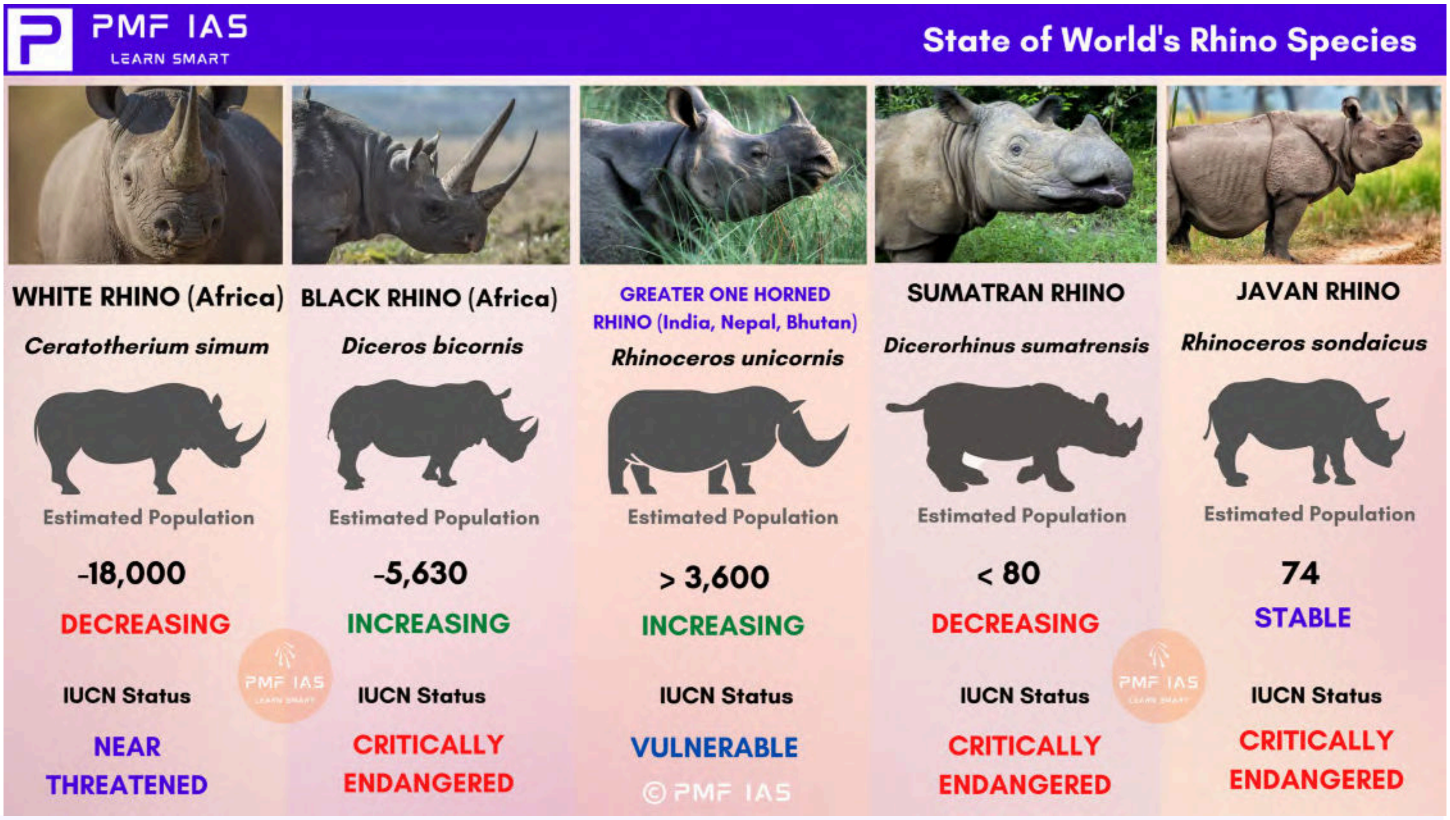
- AsESG is a global network of **voluntary specialists** concerned with the study, monitoring, management, and conservation of Asian elephants.
- It provides the best available scientifically grounded evidence to the abundance, distribution, and demographic status of Asian elephant populations in all **13 range states — Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Laos PDR, Malaysia, Myanmar (Burma), Nepal, Sri Lanka, Thailand, and Vietnam**.
- It is an integral part of the **Species Survival Commission (SSC) of the IUCN**.
- **Gajah** is the **bi-annual journal of the Asian Elephant Specialist Group (AsESG)**.

13.2. Conservation of India's Greater One-Horned Rhinoceros



13.2.1. Rhino Species Across the World

- **White Rhino & Black Rhino are found in Africa**. Black Rhino is smaller of the two African species.
- **Javan Rhino:** only a small number survive in **Java and Vietnam**.
- **Sumatran Rhino:** Sumatran rhino is the **smallest species of rhinoceros**. 30 to 80 Sumatran rhinos remain in the world, mostly on the **Indonesian island of Sumatra**.
- **Great One-Horned Rhino: Only the Great One-Horned Rhino is found in India**.
- Both **African and Sumatran rhinoceros have two horns**, **while the others (Indian and Javan) have a single horn**.
- Only about 24,500 rhinos survive in the wild. Of these, more than **two-thirds are white rhinos**.
- Rhinos are killed for their horns, which consist of **keratin** similar to human hair and nails and are used in **traditional medicines in parts of Asia**.

Q. Consider the following statements:

1. Asiatic lion naturally found in India only
2. Double-humped camel is naturally found in India only
3. One-horned rhinoceros is naturally found in India only

Which one of the statements given above is/are correct?

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a) 1 only
b) 2 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- **Asiatic Lions are is naturally found only in the Gir National Park of Gujarat**.
- Indian (Greater) One-Horned rhino is naturally found in India and Nepal.
- Bactrian Camel (double-humped camel) is endemic to Central Asian Cold Deserts.

Answer: a) 1 only

13.2.2. India's Greater One-Horned Rhinoceros (Indian Rhino)

- **Habitats**: Tropical & Subtropical Grasslands, Savannas, & Shrublands.
- Indian rhinos once ranged across the **entire northern part of the Indian subcontinent**.
- Now they are confined to the **alluvial grasslands of the Terai** of **India, Bhutan** & **Nepal** & the Brahmaputra basin.

- Major Populations: **Kaziranga National Park, Pobitora Wildlife Sanctuary & Manas National Park**.
- Greater One-Horned Rhino is the **largest of the rhino species** (second in size only to the Asian elephant).
- The Indian rhino's single horn is present in **both males & females**.
- **Threat:** Poached for its horn (in South-East Asian countries it is a belief that its horn has medicinal properties), Habitat loss & Habitat fragmentation.
- **Conservation Status:**
  - IUCN Red List: Vulnerable
  - ✓ **CITES: Appendix I**
  - ✓ **Wildlife Protection Act, 1972: Schedule I**

Conservation Efforts by India

- In **2005**, the Forest Department, Government of Assam adopted the ambitious Indian Rhino Vision (IRV) 2020 program in partnership with **WWF India** & the **International Rhino Foundation**.
- **New Delhi Declaration on Asian Rhinos 2019** was announced for the conservation & protection of the species by five rhino range nations (**India, Bhutan, Nepal, Indonesia** & **Malaysia**).
- GOI launched a project to create **DNA profiles of all rhinos in the country.**
- **National Rhino Conservation Strategy was launched in 2019** to conserve the Indian Rhino.

13.2.3. India Rhino Vision (IRV) 2020

- Concentrating so many rhinos in a single protected area like **Kaziranga** exposed the species to risks of calamities (epidemics, floods, massive poaching attempts).

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- Therefore in 2005, conservationists, alongside the **Bodoland Territorial Council** & **government of Assam**, came together to develop a long-term strategy to manage & protect the species.
- Their vision was to build a **3000 wild population of Greater One Horned Rhinos by 2020**, spread across **7 protected area in state of Assam**.
- Translocations are the backbone of the IRV 2020 program.
- Potential rhino habitat areas identified viz. **Manas NP, Dibru Saikhowa WLS, Laokhowa-Bura Chapori WLS** with a viable population of rhino through translocations from **Kaziranga NP** & **Pobitora WLS**.
- **Manas National Park** was selected as the first site for translocation of rhinos.
- The **Indian Rhino Vision 2020 ended** with the release of two rhinos in **Assam's Manas National Park** transported from **Pobitra Wildlife Sanctuary**.

13.2.4. Evaluation of IRV 2020

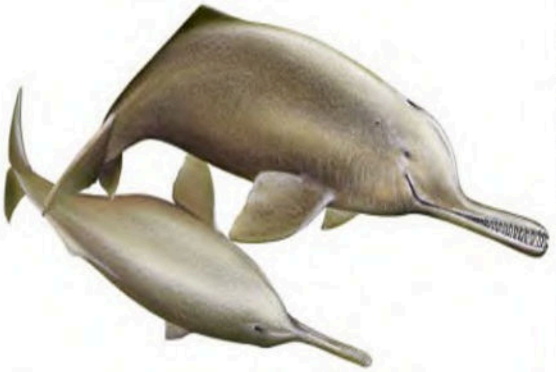
- It is believed to have **achieved its target** of attaining a population of 3000 rhinos in Assam.
- Along with the growth of a viable Rhino population, **Manas regained her (UNESCO) World Heritage Site**.
- But the plan to spread the Rhinoceros across four protected areas beyond **Kazirnaga National Park, Orang National Park** & **Pobitra WLS could not materialize**.
- Translocation to these wildlife areas (Manas) remained a daunting task as:
  - ✓ These sites continue to be vulnerable to poaching activities.
  - ✓ There is inadequate patrolling staff.
  - ✓ Translocation carried out without prior & proper security arrangement of the targeted area.
  - ✓ There was negligence towards security & health monitoring of the animals.
  - ✓ Primordial wilderness of Manas has been plagued by other challenges like – shrinking of habitat, encroachment of the corridors around the park, siltation of water bodies, & rise in invasive weeds.
  - ✓ There is unchecked growth in tourism activities, road construction along the Indo-Bhutan border.

Way forward

- Rather than Manas, the State Forest Department must diversify its search areas to include rhino range around **Pobitora & Amchang Wildlife Sanctuaries**.
- The **Brahmaputra river channel** from **Kaziranga to** Orang should also be declared as rhino zone.

13.3. Conservation of the Dolphin Species Found in Indian Waters

13.3.1. South Asian River Dolphin (*Platanista gangetica*)



- South Asian River Dolphin is divided into **2 sub-species**.
  - ✓ **Ganges river dolphin (*P. g. gangetica*)**

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- ✓ **Indus river dolphin (*P. g. minor*)**
- **Distribution: India, Bangladesh, Nepal** & **Pakistan**.
- **Threats:** Unintentional killing through entanglement in fishing gear; habitat loss and degradation – water development projects (barrages, high dams, and embankments), pollution – industrial waste and pesticides, municipal sewage discharge and noise from vessel traffic.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Ganges River Dolphin – Susu (*P. g. gangetica*)

- It is an **indicator species for the river Ganga**.
- Because of the sound it produces when breathing, the animal is popularly referred to as the '**Susu**'.
- Susu can **only live in freshwater** and is essentially blind. Hence, also known as **blind dolphin**.
- They hunt by emitting **ultrasonic sounds**.
- **Distribution:**
  - ✓ **Ganges-Brahmaputra-Meghna**
  - ✓ **Karnaphuli-Sangu river systems of Bangladesh & India**
  - ✓ **Sapta Koshi & Karnali Rivers in Nepal**.
- The **Ganges River dolphin** has been recognized by GOI as its **National Aquatic Animal** in 2009.
- It is also **State Aquatic Animal of Assam**.
- Only the **Ganges River Dolphin** is currently listed on **Convention on Migratory Species**.
- **Conservation Measures by India:**
  - ✓ **Vikramshila Gangetic Dolphin Sanctuary** in **Bihar (Only Sanctuary for Dolphin Conservation)**.
  - ✓ **Project Dolphin** on lines of Project Tiger **aims to save both river and marine dolphins,** implemented by **Environment Ministry.**
  - ✓ **Conservation Action Plan for Gangetic Dolphin (2010-2020)**
  - ✓ Included among 21 species under **Integrated Development of Wildlife Habitat**.
  - ✓ **National Ganga Council** was set up to save & enhance population of Dolphin.

Indus River Dolphin (*P. g. minor*)

- **State Aquatic Animal of Punjab**.
- **Habitat: Indus River** in Pakistan and its **Beas** and **Sutlej** tributaries.
- **River Beas** is the **only habitat** of Indus River Dolphin in India.

Q. Which one of the following is the national aquatic animal of India?

a) Saltwater crocodile
b) Olive ridley turtle
c) Gangetic dolphin
d) Gharial

Answer: c) Susu

Q. Other than poaching, what are the possible reasons for the decline in the population of Ganges River Dolphins?

1) Construction of dams and barrages on rivers
2) Increase in the population of crocodiles in rivers

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3) Getting trapped in fishing nets accidentally
4) Use of synthetic fertilizers and other agricultural chemicals in crop-fields in the vicinity of rivers

Select the correct answer using the code given below.

a) 1 and 2 only
b) 2 and 3 only
c) 1, 3 and 4 only
d) 1, 2, 3 and 4

Explanation:

- 'Susu' shares its habitat with crocodiles**,** freshwater turtles and wetland birds, many of which are fish eaters and are potential competitors with dolphins.

Answer: c) 1, 3 and 4 only

Q. If you want to see gharials in their natural habitat, which one of the following is the best place to visit? (2017)

a) Bhitarkanika Mangroves
b) Chambal River
c) Pulicat Lake
d) Deepor Beel

13.3.2. Irrawady Dolphin (Orcaella brevirostris)

- **Habitat: Unlike** South Asian River Dolphin**,** the Irrawady Dolphin lives in **brackish water** near coasts, river mouths, and estuaries & in freshwater rivers, including the **Ganges** & **Mekong**, as well as the **Irrawaddy River** from which it takes its name.
- **Distribution:** Concentrated lagoon populations in India are found in **Chilika Lake in Odisha**.

- **Threats:** Human conflict, drowning in gillnets is the main threat to them throughout their range.
- It is also included under **Convention on Migratory Species (CMS).**
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

13.3.3. Project Dolphin (Proposed)

- In 2020, Prime Minister Modi announced the government's plan to launch Project Dolphin.
- Such an initiative got in-principal approval in December 2019, at the first meeting of the **National Ganga Council (NGC), headed by the Prime Minister**.
- The proposed project is **aimed at saving both river and marine dolphins**.
- it is expected to be implemented by the **Ministry of Environment**.

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- Project Dolphin will be on the lines of Project Tiger, which has helped increase the tiger population.
- So far, the **National Mission for Clean Ganga (NMCG)**, which implements the government's flagship scheme **Namami Gange**, has been taking some initiatives for saving dolphins.

13.3.4. Ganges River Dolphin Conservation Measures by India

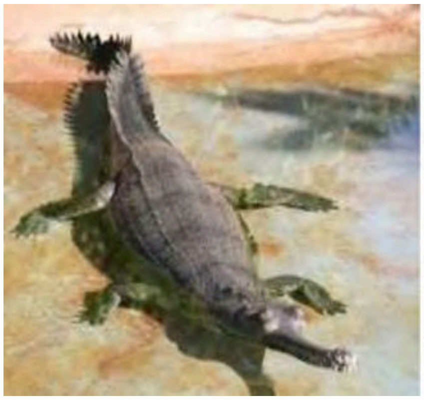
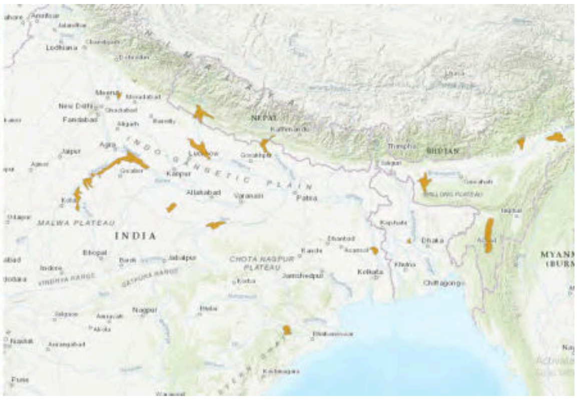
- ✓ After the launch of **Ganga Action Plan in 1985**, the government included Gangetic dolphins in the **First Schedule of the Indian Wildlife (Protection), Act 1972**.
- ✓ **Vikramshila Gangetic Dolphin Sanctuary in Bihar** (only Sanctuary for Dolphin Conservation) was created.
- ✓ **Project Dolphin** on lines of Project Tiger aims to save **both river and marine dolphins**.
- ✓ **Conservation Action Plan for Gangetic Dolphin (2010-2020):** identified threats to Gangetic Dolphins and impact of river traffic, irrigation canals and depletion of prey-base on Dolphins populations.
- ✓ **Ganges River Dolphin** is included among 21 species under **Integrated Development of Wildlife Habitat**.
- ✓ **National Ganga Council** was set up to save & enhance population of Dolphin.
- ✓ In 2009, the then Prime Minister while chairing the maiden meeting of the **National Ganga River Basin Authority**, declared the **Gangetic River dolphin as the national aquatic animal**.
- ✓ The **National Mission for Clean Ganga celebrates October 5** as **National Ganga River Dolphin Day**.

13.4. Conservation of India Crocodile Species

13.4.1. Crocodile Species in India

Gharial (CR)

- Gharial are **fish-eating freshwater crocodile**.
- It is amongst the **longest** of all living crocodilians.
- **Habitat:** clean rivers with sand banks.
- **Gharials (Critically Endangered)** once thrived in all the major river systems of the Indian subcontinent.
- Today, they are extinct in the Indus, the Brahmaputra of Bhutan and Bangladesh, and in the Irrawaddy River.
- **Distribution:**
  - ✓ Only viable population in the **National Chambal Sanctuary** spread across **3 states of Uttar Pradesh, Rajasthan and Madhya Pradesh**,
  - ✓ Small non-breeding populations exist in **Son, Gandak, Hoogly, Ghagra rivers** & **Satkosia Sanctuary (Odisha).**

- **Threats:** The combined effects of dams, barrages, artificial embankments, change in river course, pollution, sandmining, riparian agriculture and ingress of domestic and feral livestock.
- **Conservation Status:**
  - ✓ **IUCN Red List Status: Critically Endangered**

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- ✓ **WPA: Schedule I**
- ✓ **CITES: Appendix I**

Mugger/Indian Crocodile/Broad Snouted Crocodile

- The **mugger (marsh/India) crocodile (Vulnerable)** is a **freshwater species** found sparsely in various lakes, rivers and marshes in the Indian subcontinent.
- **Habitat:** Inhabits freshwater lakes, rivers and marshes, and prefers slow-moving, shallow water bodies. It is also thriving in **artificial reservoirs & irrigation canals.**
- **Distribution: Found throughout India**. Extinct in Bhutan.

- **Threats:** Habitat destruction because of conversion of natural habitats for agricultural & industrial use, fishing, sacrificed in superstitious practices or used as aphrodisiacs.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Saltwater Crocodile

- Saltwater Crocodile is the **largest** living reptile and crocodilian known to science.
- Apart from the eastern coast of India, the **saltwater crocodile (Least Concern)** is extremely rare on the Indian subcontinent.
- **Habitat:** Saltwater habitats and brackish wetlands.
- **Distribution:** India's east coast (**Odisha's Bhitarkanika Wildlife Sanctuary, Andaman and Nicobar Islands coasts & Sundarbans**), across Southeast Asia and the Sundaic region to northern Australia.

- **Threat:** Hunted for its skin, threatened by illegal killing & habitat loss.
- **Conservation Status:**
  - **IUCN Red List Status:** Least Concern
  - **WPA: Schedule I**
  - **CITES:** Appendix I

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⇨ **All the three crocodile species are included in WPA: Schedule I** and **CITES: Appendix I**

13.4.2. Indian Crocodile Conservation Project

- The Indian Crocodile Conservation Project has pulled back the once threatened crocodilians from the brink of extinction and place them on a good path of recovery.

Objectives

- To protect the remaining population of crocodilians in their natural habitat by creating sanctuaries.
- To rebuild natural population quickly through 'grow and release' or 'rear and release' technique.
- To promote captive breeding.
  - ⇨ *Captive breeding means that members of a wild species are captured, then bred and raised in a special facility under the care of wildlife biologists and other experts.*
  - ⇨ *Bringing an animal into captivity may represent the last chance to preserve a species in the wild.*
- To take up research to improve management.
- To build up a level of trained personnel for better continuity of the project.
- To involve the local people in the project intimately

13.4.3. Madras Crocodile Bank Trust

- It is a reptile zoo and research station on the outskirts of Chennai.
- It was established to save Indian EN species of crocodile — the **marsh or mugger crocodile (VU), the saltwater crocodile (LC), and the gharial (CR)**.
- The place offers a secure nesting beach for **olive ridley sea turtles**.
- It has one of the world's largest collections of crocodiles and alligators.

13.5. Conservation of Sea Turtles

13.5.1. Turtle Found in India

CR – Black Softshell Turtle

- Black Softshell turtle is a species of **freshwater turtle**.
- **Habitat: Lower Brahmaputra River**.
- **Distribution:** They are found in **ponds of temples** in **north-eastern India.**

- **Conservation Status:**
  - ✓ **IUCN Red List status:** Critically Endangered
  - ✓ **CITES:** Appendix I

CR – Hawksbill Turtle

- Hawksbill Turtle species is **migratory in nature** & nesting occurs in about 70 countries across the world.

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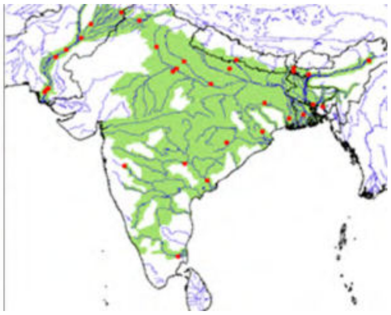
- Maturation is slow and is estimated between 25 — 40 years.
- **Habitat:** Nesting occurs on insular, sandy beaches.
- **Distribution:** In India, they are found in the Andaman and Nicobar Islands, the coast of Tamil Nadu & Orissa.

- **Threats:** Turtle shell trade, egg collection, slaughter for meat, oil pollution and destruction of nesting and foraging habitats.
- **Conservation Status:**
  - ✓ **IUCN Red List Status: Critically Endangered**
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

CR – Indian Narrow Headed Softshell Turtle

- Indian Narrow-Headed Softshell Turtle **(Small-Headed Softshell Turtle)** is species found in rivers of the Indian Sub-continent like **Sutlej, Indus, Ganges, Brahamputra, Mahanadi, Padma etc.**
- **Distribution:** Indus, Ganges, Godavari, and other rivers basins of India, Nepal and Bangladesh.



- **Conservation Status:**
  - ✓ **IUCN Red List:** Endangered
  - ✓ **WPA: Schedule IV**
  - ✓ **CITES:** Appendix II

CR – Red Crowned Roofed Turtle/Bengal Roof Turtle

- Red Crowned Roofed Turtle is a species of **freshwater turtle endemic to South Asia**.
- **Habitat:** deep, flowing rivers but with terrestrial nest sites.
- **Distribution:** Found in India (**National Chambal Sanctuary** to WB), Bangladesh and Nepal.
- **Threats:** development projects, water pollution, human disturbance and poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List:** Critically Endangered
  - ✓ **CITES:** Appendix II

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EN – Green Sea Turtle

- **Habitat:** the habitat of **Green Turtle** is extended throughout tropical & subtropical seas around the world.
- **Threats**: Hunting, poaching and egg harvesting.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

EN – Indian Softshell Turtle (Ganges softshell turtle)

- The Indian softshell turtle is a species of softshell turtle found in **South Asia**.
- **Distribution:** Ganges, Indus, and Mahanadi.

- **Conservation Status:**
  - ✓ **IUCN Red List status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

EN – Peacock Softshelled Turtle

- Peacock Softshelled Turtle is a species of turtle native to **South Asia.**
- **Habitat:** These are found in rivers, streams, lakes and ponds with mud or sand bottoms.
- **Distribution:** This species is **confined to India, Bangladesh, and Pakistan**.

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- **Threats:** Overfishing, pollution, increase in river traffic, and sand mining, among others. The species is heavily exploited for its meat and calipee (the outer cartilaginous rim of the shell).
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA :Schedule I**
  - ✓ **CITES:** Appendix I

VU – Leatherback Turtle

- Leatherback Turtle is the **largest of the living sea turtles**, weighing as much as 250-700 kg.
- **Jellyfish** is their primary food.
- **Habitat:** Tropical and subtropical oceans.
- **Distribution:** Found in tropical and temperate waters of the Atlantic, Pacific, and into Indian Oceans.

- **Threats:** High sea fishing operations, harvesting of eggs, destruction of nests by wild predators and domesticated species such as cats, dogs and pigs, artificial lighting disorients hatchlings and adults and causes them to migrate inland rather than towards the sea.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Q. Consider the following fauna of India:

1) Gharial
2) Leatherback turtle
3) Swamp deer

Which of the above is/are endangered?

a) 1 and 2 only
b) 3 only
c) 1, 2 and 3
d) None

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Explanation:

- Gharials are 'Critically Endangered'. **Swamp deer (barasingha) (VU)** and **Leatherback turtle** are 'Vulnerable'.

Answer: d) none

VU – Olive Ridley Sea Turtle

- The Olive Ridley Sea Turtle (Pacific ridley sea turtle) is the **smallest** of all marine turtle species.
- A significant proportion of the world's Olive Ridley Sea Turtle **(VU)** population migrates **every winter** to Indian coastal waters for nesting, mainly at the eastern coast.
- **Distribution:** They are found in warm and tropical waters of the Pacific, Atlantic and Indian Oceans.

- Olive ridley turtles are best known for their **synchronized nesting** in mass numbers called **Arribada**.
- **Gahirmatha Marine Sanctuary** & **Rushikulya Rookery Coast** are the main **Nesting sites** in India.
- Mass mating picks up in December and continues till the month of January.
- **Threats:** Unsustainable egg collection, slaughtering nesting females on the beach, and direct harvesting adults at sea for commercial sale of both the meat and hides, coastal development, natural disasters, climate change, and other sources of beach erosion.

- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

13.5.2. Sea Turtle Conservation Project

- With the objective of conservation of olive ridley turtles and other **endangered marine turtles**, MoEF initiated the **Sea Turtle Conservation Project** in collaboration of **UNDP** in 1999 with **Wildlife Institute of India, Dehradun** as the Implementing Agency.
- The project is being implemented in 10 coastal states of the country, with special emphasis in Odisha.
- The project has helped in the preparation of an inventory map of breeding sites of Sea Turtles, identification of nesting and breeding habitats along the shoreline, and migratory routes taken by Sea Turtles, etc.
- One of the important achievements have been demonstration of use of Satellite Telemetry to locate the migratory route of Olive Ridley Turtles in the sea and sensitizing the fishermen and State Government for the use of Turtle Exclusion Device (TED) in fishing trawlers to check turtle mortality in fishing net.

13.6. Conservation of Indian Vultures

- India is the most favourable region for Vultures: Hindus do not eat cows, which they consider sacred, and when a cow dies, it is left to be fed on by vultures.

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- India has **high species diversity,** and hence vultures get a lot of food.
- **9 species** of vulture can be found living in India. But today, most are in danger of extinction due to a veterinary drug called **diclofenac** (vultures do not have a particular enzyme to break down diclofenac).

13.6.1. Diclofenac and Indian Vulture Crisis

- **Diclofenac** is a common **anti-inflammatory drug administered to livestock** & is used to treat the symptoms of inflammation, fevers and/or pain associated with disease or wounds.
- It leads to **renal failure in vultures damaging their excretory system** (direct inhibition of uric acid secretion in vultures).
- ***Gyps* species** were the most affected by diclofenac.
  - ✓ The population of the **White-Rumped Vulture** fell 99.7% between 1993 and 2002.
  - ✓ The populations of the **Indian vulture & the slender-billed vulture** fell 97.4%.
- 2 other species of *Gyps*, **Himalayan vulture & Eurasian griffon,** were less affected because they come to India **only in winters.**
- They are exclusively mountain-dwelling and hence less vulnerable to diclofenac contamination.

Consequences of Depopulation of Vultures

- Vultures previously played an important role in public sanitation in India & their disappearance has resulted in an **explosion of rats and wild dogs and the spread of diseases** resulting in an estimated cost of up to ₹1700 billion (US$25 billion) (as of 2015).
- The carcasses formerly eaten by vultures' rot in village fields leading to **contaminated drinking water**.
- These newly abundant scavengers are not as efficient as vultures. A **vulture's metabolism is a true "dead-end" for pathogens**, but dogs and rats become carriers of the pathogens.
- The mammals also carry diseases from rotting carcasses such as rabies, anthrax, plague etc. and are indirectly responsible for thousands of human deaths.

13.6.2. Conservation Status of India Vultures

Critically Endangered

- White-Rumped Vulture
- White-Backed Vulture
- Ruppell's Vulture
- Indian Vulture
- Slender-Billed Vulture

Endangered

- Cape Vulture

Near Threatened

- Himalayan Vulture

Least Concern

- Griffon Vulture

Critically Endangered

White-Rumped Vulture

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- The white-Rumped vulture was very common especially in the **Gangetic plains of India**, and often seen nesting on the avenue trees within large cities in the region.

White-Backed Vulture

Ruppell's Vulture

Indian Vulture (*Gyps indicus*)

- The Indian vulture is found only to the **south of the Ganges** and breeds on cliffs.

Slender-Billed Vulture

- The slender-billed vulture is found along the Sub-Himalayan regions and into Southeast Asia.

Endangered

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Cape Vulture

Near Threatened

Himalayan Vulture/Himalayan Griffon Vulture

- Found along the **Himalayas & adjoining Tibetan Plateau.**
- Recently, Himalayan griffon vulture has been sighted for the first time at the **Point Calimere WLS (TN).**
- **CITES: Appendix II**

Least Concern

Griffon Vulture

13.6.3. Steps taken by the government

- The Protection status of **White-backed, Long-Billed (Indian Vulture) & Slender Billed Vultures** was upgraded from **Schedule IV to Schedule I** of the Wild Life (Protection) Act, 1972.
- The species is under '**Species Recovery Programme**'.
- **Vulture Restaurants** are created where tables are reserved only for the unique and rare vultures by Maharashtra and Punjab Forest departments.
- **Central Zoo Authority (CZA) & Bombay Natural History Society (BNHS)** led the establishment of the **Vulture Conservation Breeding Programme** (programme has been highly successful).
- **Vulture Safe Zones** are created to conserve the remaining population & facilitate **reintroduction of vultures into the wild** from **Vulture Conservation Breeding Centres (VCBCs).**

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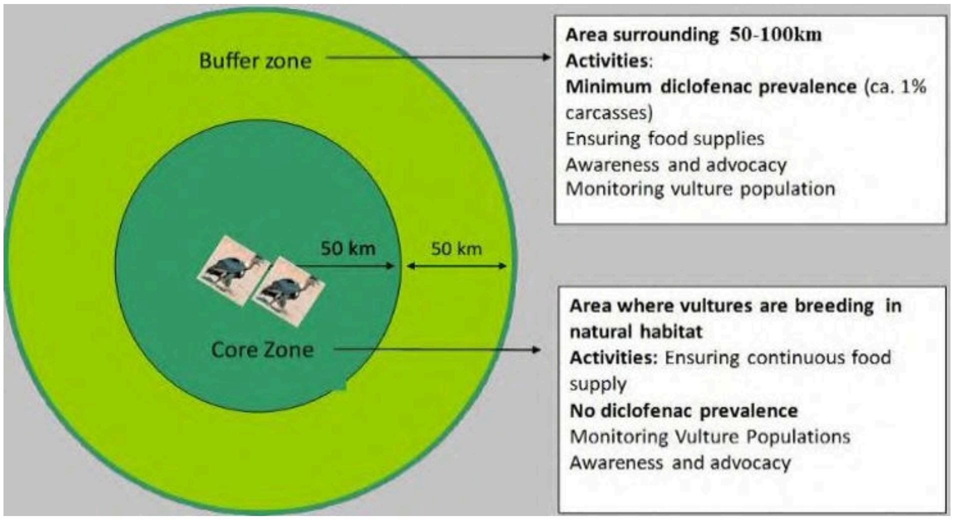
Vulture Safety Zones (VSZ)

- Aim of developing VSZs is to **establish targeted awareness** activities surrounding **150 km radius** of vultures' colonies so that **no diclofenac or the veterinary toxic drugs are found** in cattle carcasses.



- The VSZ is spread around in several hundred kilometres covering the **Jim Corbett in Uttarakhand, Dudhwa and Kartamiaghat forest reserves in UP** which is adjoining the Indo-Nepal border.
- Nepal has already set up VSZ on the Indian borders.

Action Plan for Vulture Conservation

- **Action Plan for Vulture Conservation (APVC) 2006** was released to save the vultures from possible extinction.
- **Main objectives were:**
    1) Removal of the Main Causative Agent for vulture mortality i.e. diclofenac
    2) Raising Awareness especially among Users of Veterinary Formulations

Action Plan for Vulture Conservation in India (APVC) 2020-2025

- Action plan project is extended to 2025 aiming not just halting the decline but to actively increase the vulture numbers in India.
- **Main objectives are:**

1) It ensures that sale of veterinary **NSAIDs is strictly regulated.**

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2) To carry out **safety testing of available molecules of veterinary NSAIDs** on vultures & to introduce new molecules in the market only after they are proved to be safe following safety testing on vultures.
3) It includes **drugs other than diclofenac** that are toxic to vultures like **Aceclofenac** & **Ketoprofen** to **be banned for veterinary use**.
4) It **covers all 9 species of vultures** recorded from India (**Includes Red Headed Vulture & Egyptian Vulture** in the Vulture Conservation Breeding Centres).
5) To have **at least 1 vulture safe zone in each state**.

Diclofenac Alternative

- The drug was **banned for veterinary use** in India in **March 2006.**
- A replacement drug was quickly developed and proposed after tests on vultures in captivity: **Meloxicam**.
- **Meloxicam** affects cattle the same way as diclofenac but is **harmless for vultures.**
- Diclofenac for human use was still being diverted into veterinary uses through black markets in certain parts of India.

13.7. Other National Efforts Towards Wildlife Conservation

13.7.1. Hangul Conservation Project (HCP) or Project Hangul (Kashmiri stag)

- The **hangul/Kashmiri stag (CR)** is a subspecies of **Central Asian Red Deer** native to northern India.
- It was the state animal of erstwhile Jammu & Kashmir.
- In Kashmir, it is found in **Dachigam National Park** at **elevations of 3,035 meters**.
- These deer once numbered from about 5,000 animals in the beginning of the 20th century.
- They are now threatened due to habitat destruction, over-grazing by domestic livestock and poaching.
- The species dwindled to as low as 150 animals by 1970.
- The **state of Jammu & Kashmir**, along with the **IUCN** and the **WWF** prepared **Project Hangul** for the protection of these animals and the population increased to over 340 by 1980.
- According to the census in 2019, there were only 237 Hanguls.

13.7.2. Integrated Development of Wildlife Habitats (IDWH)

- Integrated Development of Wildlife Habitats (IDWH) is an on-going **Centrally Sponsored Scheme**.
- Under IDWH, **financial assistance is provided to State/UTs** for protection and conservation of wildlife.

Components of the scheme

1. **Support to Protected Areas** (National Parks, Wildlife Sanctuaries, Conservation & Community Reserves)
2. **Protection of Wildlife Outside Protected Areas**
3. **Species Recovery Programmes** for **saving critically endangered species and habitats**.

The list of critically endangered (locally) species under Species Recovery Programme

1. **Asian Wild Buffalo**
2. **Asiatic Lion**
3. **Brow-Antlered Deer or Sangai**
4. **Dugong**
5. **Edible Nest Swiftlet**
6. **Gangetic River Dolphin**
7. **Great Indian Bustard**
8. **Hangul**

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9. **Indian Rhino or Great One-horned Rhinoceros**
10. **Jerdon's Courser**
11. **Malabar Civet**
12. **Marine Turtles**
13. **Nicobar Megapode**
14. **Nilgiri Tahr**
15. **Snow Leopard**
16. **Swamp Deer**
17. Vultures (entire group of species found in India)
18. **Northern River Terrapin**
19. **Clouded Leopard**
20. **Arabian Sea Humpback Whale**
21. **Red Panda**
22. **Caracal cat (recently added)**

- Conservation of the species included in **Indian critically endangered list** will get **financial assistance** from **Integrated Development of Wildlife Habitat (IDWH)**.

13.7.3. Animal Welfare Board of India (not to be confused with National Board for Wildlife)

- **Animal Welfare Board of India (AWBI) (not to be confused with National Board for Wildlife (NBWL))** is a **statutory advisory body** advising the government on animal welfare laws and promotes animal welfare in India.
- It was **established in 1960** under Section 4 of **The Prevention of Cruelty to Animals Act, 1960**.
- The subject of Prevention of Cruelty to Animals was under **MoEF till 2019**. It is now transferred to **MFAHD**.
- **AWBI** functions under the aegis of **Ministry of Fisheries, Animal Husbandry and Dairying (MFAHD – Department of Animal Husbandry and Dairying)**. (It was transferred from MoEF to MFAHD in 2019)
- It works to ensure that animal welfare laws in the country are followed; provides grants to Animal Welfare Organizations; and considers itself "the face of the animal welfare movement in the country."
- Well-known humanitarian **Rukmini Devi Arundale** was instrumental in setting up the board.

Functions

- The board is highly concerned about "**abuse of animals in research**" and "**cruelty involved when animals were used in entertainment**".
- The Board oversees **Animal Welfare Organizations (AWOs)** by **granting recognition** to them.
- The Board provides **financial assistance** to recognized Animal Welfare Organizations (AWOs)
- The Board suggests **changes to laws and rules** about animal welfare issues.
- The Board issues publications to **raise awareness** of various animal welfare issues.

Q. Consider the following statements:

1) Animal Welfare Board of India is established under the Environment (Protection) Act, 1986.
2) National Tiger Conservation Authority is a statutory body.
3) National Ganga River Basin Authority is chaired by the Prime Minister.

Which of the statements given above is/ are correct?

a) 1 only
b) 2 and 3 only
c) 2 only

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d) 1, 2 and 3

Explanation:

- **Genetic Engineering Appraisal Committee (GEAC)** is the **statutory body** constituted in the **MoEF** under 'Rules 1989', under the **Environment Protection Act, 1986**.
- The **National Board for Wildlife (NBWL)** is a "**statutory board**" constituted under the **Wild Life (Protection) Act, 1972 (wildlife act)**
- **Animal Welfare Board of India** is established in the **MoEF and was** transferred to **MFAHD** in 2019. It derives it powers under the **Prevention of Cruelty to Animals Act**.

Answer: b) 2 and 3 only

13.7.4. National Wildlife Action Plan (NWAP) 2017-2031

- **1st National Wildlife Action Plan** was drafted & adopted in 1983.
- **2nd National Wildlife Action Plan** was put in place for the period (2002 – 2016).
- **3rd National Wildlife Action Plan is for the period 2017 – 2031**.
- The NWAP has 5 components, 17 themes, 103 conservation actions and 250 projects.

Components of 3rd National Wildlife Action Plan (2017 – 2031)

1) Strengthening & promoting the integrated management of wildlife and their habitats.
2) Adaptation to climate change and promoting integrated sustainable management of aquatic biodeiversity.
3) Promoting eco-tourism, nature education & participatory management
4) Strengthening wildlife research and monitoring of development of human resources in wildlife conservation
5) Enabling policies and resources for conservation of wildlife in India.

Significant Features

- NWAP adopts the **Landscape approach of conservation**.
- It also underscores the **role of private sector in the wildlife protection** by ensuring adequate fund flow from the **Corporate Social Responsibility (CSR) fund**.
- It also emphasizes upon two other aspects of nature conservation i.e., **preservation of genetic diversity** & **sustainable utilization of species and ecosystem.**
- Some **new issues have been considered** in the 3rd National Wildlife Action Plan. These issues include:
  - ✓ Climate change and wildlife
  - ✓ Wildlife health
  - ✓ Inland, coastal and marine conservation
  - ✓ Wildlife conflict mitigation.

Landscape Approach

- Landscape Approach to conservation is a **holistic approach to landscape management,** aiming to reconcile the competing objectives of nature conservation and economic activities across a given landscape.
- It is based on the importance of **conservation of uncultivated flora and undomesticated fauna** that had ecological value **irrespective of their place of occurrence.**
- It can be seen as an **alternative to site-based conservation i.e.** strategies more concentrated on national parks and wildlife sanctuaries.

13.7.5. National Action Plan for Conservation of Migratory Birds (2018 – 2023)

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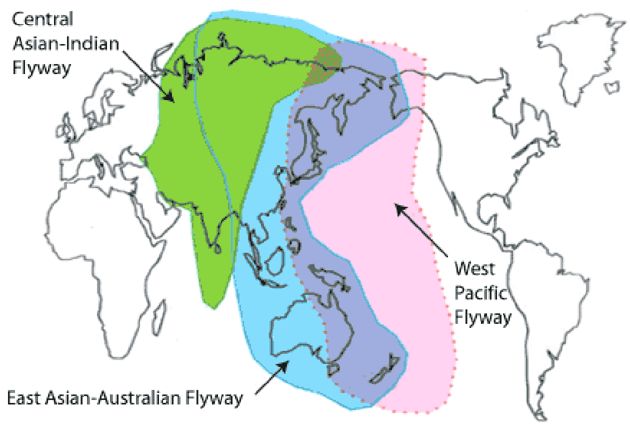
- **MOEFCC** has developed the plan for Conservation of Migratory Birds & their Habitats along **Central Asian Flyway (CAF)** for the **period 2018-23.**
- Longer-term goal is to **arrest population decline & secure habitats** of migratory bird species.
- In Short run plan seeks to halt the downward trends in declining meta-populations by **2027.**

Central Asian Flyway (CAF)

- **Flyways** are used by groups of birds during their **annual cycle** which includes **breeding areas, stop over areas & wintering areas.**
- Many of these areas are used by birds are highly productive & also enable benefits to local people.
- The Central Asian Flyway (CAF), **1 among the 9 flyways** identified under **Convention on Migratory Species**.

Asian Migratory Bird Flyways



- **Route Extends: Russia (Siberia)** to the southernmost non-breeding (wintering) grounds in **West & South Asia**, the **Maldives & British Indian Ocean Territory**.
- India has a strategic role in the flyway, as it provides critical **stopover sites to over 90% of the bird species** known to use this migratory route.

13.7.6. Green Good Deeds Initiative

- The MoEF coordinates a Central Sector Scheme called '**Environment Education, Awareness and Training**'.
- The 'Green Good Deeds' initiative is about simple, practical steps that students/teachers/citizens can perform in their day-to-day life towards protection of environment.
- The objective is to promote environmental awareness among all sections of the society.
- A component of this scheme is the **National Green Corps** (NGC) programme.
- Under NGC, 1.5 lakh Eco Clubs have been established in schools/colleges across the country.
- Students are actively involved in the NGC programmes related to environment protection and conservation.
- Activities of **EcoClubs** include conducting cleanliness drives as part of Swachh Bharat Abhiyan, plantation drives, awareness on waste minimization, waste segregation, recycling and reuse.

13.7.7. Bombay Natural History Society

- The Bombay Natural History Society, founded in 1883, is one of the largest non-governmental organizations in India engaged in **conservation and biodiversity research**.
- It supports many research efforts through grants and publishes the **Journal of the Bombay Natural History Society**.
- It organizes and conducts nature trails and camps for the general public.
- Many prominent naturalists, including the ornithologists Sálim Ali and S. Dillon Ripley, have been associated with it.

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Q. With reference to Bombay Natural History Society (BNHS), consider the following statements:

1) It is an autonomous organization under the Ministry of Environment and Forests.
2) It strives to conserve nature through action-based research, education and public awareness.
3) It organizes and conducts nature trails and camps for the general public.

Which of the statements given above is/are correct?

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: 2 and 3 only

13.8. International Efforts Towards Wildlife Conservation

13.8.1. World Wildlife Fund for Nature (WWF)

- **World Wide Fund for Nature** is an **NGO** established in 1961 and is headquartered at Gland, Switzerland.
- It was formerly named the **World Wildlife Fund**.
- It works in the field of **wilderness preservation**, and the **reduction of human impact** on the environment.
- WWF aims to "**stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature**."

Initiatives by WWF

- **The Wildlife Trade Monitoring Network (TRAFFIC, an NGO)** is a joint programme of **WWF** and **IUCN**.
- **Living Planet Report** has been published **every two years** by WWF since 1998.
- WWF has launched notable worldwide campaigns like **Earth Hour** and **Debt-for-Nature Swap**.

Q. Consider the following statements regarding 'Earth Hour' (UPSC Prelims 2014).

1. It is an initiative of UNEP & UNESCO.
2. It is a movement in which the participants switch off the lights for one hour on a certain day every year.
3. It is a movement to raise the awareness about the climate change & the need to save the planet.

Which of the statements given above is / are correct?

a) 1 & 3 only
b) 2 only
c) 2 & 3 only.
d) 1, 2 & 3

Answer: c)

Earth Hour

- **Earth Hour** is a worldwide movement organized by the **WWF**.
- It encourages people worldwide to switch off the lights from 8.30 pm to 9.30 pm as per their local time.
- It was started in 2007 and is held every year on the **last Saturday of March**.
- Earth Hour 2021 was held on March 27, from 8:30 pm to 9:30 pm.

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- The idea is to refrain from the use of non-essential lighting to save energy in a symbolic call for environmental protection.
- Earth Hour has been successful in pursuing legislative changes by harnessing the power of the people and collective action.
- For example, it helped
  - ✓ Create a 3.5-million-hectare marine-protected area in Argentina
  - ✓ Ban all plastics in the **Galapagos** in 2014, etc.

Similar Topic: Earth Day Network (EDN) & Earth Day – April 22

- **Earth Day** is an annual event, organized by **Earth Day Network (EDN, an NGO)** to show support for environmental protection around the world on April 22. This day commenced on April 22, 1970.
- In the year 2020, the **50th anniversary** of the first Earth Day is being celebrated.
- The theme for Earth Day 2020 is "**climate action**".
- The mission of Earth Day Network (EDN) is to diversify, educate and **activate the environmental movement worldwide**.

13.8.2. International Whaling Commission

- It is **not an organ of UN**.
- It is set up by terms of **Internal Convention for Regulation of Whaling (ICRW)**.
- It provides for the **proper conservation of whale stocks** & orderly development of the whaling industry.
- It can **designate areas as whaling sanctuary**.
  - ✓ **Southern Ocean Whale Sanctuary (Antarctica)**
  - ✓ **Indian Ocean Whale Sanctuary (Seychelles)**
- **HQ: United Kingdom**
- Participation in IWC **not limited to states involved in Whaling**.
- **India is a member**.
- In **1982** it adopted **Moratorium on Commercial Whaling**.
  - ✓ Moratorium of 1982 applies only to commercial whaling.
  - ✓ Whaling under **Scientific Research and aboriginal subsistence provisions** of ICRW are **still allowed**.
- **Florianopolis Declaration:** In Sep 2018, IWC members gathered in Florianopolis (Brazil), where they rejected proposal by Japan to renew Commercial Whaling.
- As a result, **Japan announced its withdrawal**.

13.8.3. Evolutionarily Distinct and Globally Endangered Species (EDGE SPECIES)

- The EDGE of Existence programme is a **global conservation initiative** to focus **specifically on threatened species** that represent a significant amount of unique evolutionary history.
- The EDGE have **few or no close relatives** on the tree of life.
- EDGE species are usually **extremely distinct** in the way they look, live, and behave as well as in their genetic make-up.
- **If they disappear**, there will be nothing like them left on the planet.
- **EDGE programme** aims at ensuring **future survival of EDGE Species.**

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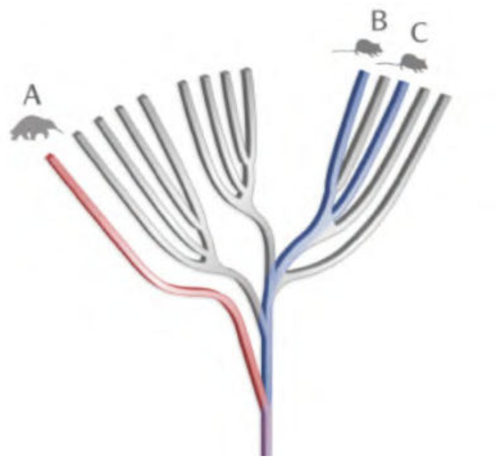

- **Species A** has a **higher EDGE score** than either species B or C.
- If species A were to go extinct, there would be no similar species left on the planet.

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14. India State of Forest Report 2019 (ISFR 2019)

- Every **two years (biennial)**, **Forest Survey of India** undertakes assessment of country's forest resources.
- The results are presented as the '**India State of Forest Report (ISFR – biennial report)**'.
- Since 1987, 15 such assessments have been completed and the 2019 assessment is the **16th** in the series.

14.1. Forest Survey of India (FSI)

- Forest Survey of India (FSI) is a national organization under the **Ministry of Environment**.
- It is established in 1981 and has its headquarters at **Dehradun**.
- It is responsible for **assessment and monitoring of the forest resources** of the country on regular basis.

14.1.1. Objectives of FSI

- To prepare **State of Forest Report biennially**.
- To conduct inventory in forest and non-forest areas and develop database on forest tree resources.
- To function as a **nodal agency** for **collection and dissemination of spatial database on forest resources**.
- To conduct **training** of forestry personnel in application of technologies related to remote sensing, GIS, etc.
- To support State/UT Forest Departments (SFD) in forest resources survey, mapping and inventory.

14.1.2. The major activities of FSI

1. **Remote sensing based** nation-wide **forest cover mapping** in **biennial cycle**,
2. **National forest inventory**,
3. **Forest fire monitoring**,
4. **Forest carbon assessment**,
5. **Forest type mapping** and several projects on emerging issues.

- FSI undertakes **National Forest Inventory** to assess the growing stock in
  - ✓ forests and **Trees Outside Forests (TOF or outside Recorded Forest Area (RFA)**),
  - ✓ **bamboo resource**,
  - ✓ **carbon stock** along with several other parameters.

14.2. Important Terms

- **Recorded forest area (RFA)** ➔ lands **notified as forest** under **any Government Act or Rules**.
- **Tree cover** ➔ includes **all patches of trees less than 1 ha** (density does not matter) **outside RFA**.
- **Tress Outside Forests (TOF)** ➔ **all trees outside RFA irrespective of patch size**.
- **Forest cover** ➔ **all patches of land** with a
  - ✓ **tree canopy density of more than 10% and**
  - ✓ **more than 1 ha in area**, **irrespective of land use**, **ownership** and **species of trees**.
- **Three canopy density classes are:**
  1. **Very Dense Forest ➔ canopy density more than 70%,**
  2. **Moderately Dense Forest ➔ canopy density between 40-70%** and
  3. **Open Forest ➔ canopy density between 10-40%** (**below 10% it is scrubland**).

Tree cover ➔ less than 1 ha + **outside RFA**

Tress Outside Forests (TOF) ➔ Any tree outside RFA

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Forest cover → more than 1 ha + tree canopy density of more than 10%

14.3. The summary of the key findings of ISFR 2019

GA: Geographic Area

- **Total Forest cover (canopy density > 10% + more than 1 ha) → 7,12,249 sq km** (**21.67%** of GA).
- **Total Tree cover (patches of trees less than 1 ha) → 95,027** (**2.89%** of GA).
- **Total Forest and Tree cover → 8,07,276 sq km** (**24.56%** of GA).
- Total Forest cover in the hill districts → 2,84,006 sq km (**40.30%** of the area of these districts).
- Total Forest cover in the tribal districts → 4,22,351 sq km (**37.54%** of the area of these districts).
- **Total Forest cover in the North Eastern region →** 1,70,541 sq km (**65.05%** of its geographical area).
- Total bamboo bearing area → 1,60,037 sq km.
- **Total carbon stock** in forest → **7,124.6 million tonnes (7.1 billion tonnes)**
- As compared to ISFR 2017, The current assessment shows an **increase** of
  - ✓ 3,976 sq km (**0.56%**) of forest cover ↑,
  - ✓ 1,212 sq km (**1.29%**) of tree cover ↑ and
  - ✓ 5,188 sq km (**0.65%**) of forest and tree cover put together ↑
- As compared to ISFR 2017, Forest cover
  - ✓ **within the Recorded Forest Area (RFA)** has shown a **slight decrease** of 330 sq km.
  - ✓ **outside the Recorded Forest Area (RFA)** has shown a **slight increase** of 4,306 sq km.
  - ✓ in the **North East states** (except **Assam** and **Tripura**) has shown a **decrease** to the extent of 765 sq km.
- The top five States in terms of increase in forest cover are:
  1. **Karnataka** (1,025 sq km),
  2. **Andhra Pradesh** (990 sq km),
  3. **Kerala** (823 sq km),
  4. **Jammu & Kashmir** (371 sq km) and
  5. **Himachal Pradesh** (334 sq km).
- **21.40%** of the forest cover of the country is **highly to extremely fire prone**.
- **Mangrove cover** in the country has **increased** by 54 sq km (1.10%).
- There is an increase of 3,229 sq km in bamboo bearing area.
- There is an **increase** of 42.6 million tonnes in the **carbon stock**.
- **Soil Organic Carbon** (SOC – **carbon component of soil organic matter** – 4,004 million tonnes) represents the largest pool of carbon stock in forests.
- The SOC contributes **56% to the total forest carbon stock of the country**.
- There are 62,466 wetlands covering 3.83% of the area within the RFA of the country.
- The total number of wetlands located within the RFA is 8.13% of the total number of wetlands in India.
- **Gujarat has largest area of wetlands within RFA** in the country followed by **West Bengal**.
- The total growing stock of wood in the country is estimated 5,915.76 million cum comprising:
  - ✓ 4,273.47 million cubic meters (million cum) inside RFA and
  - ✓ 1,642.29 million cum outside recorded forest areas (TOF).
- Dependence of fuelwood on forests is highest in the State of **Maharashtra**, whereas, for fodder, small timber and bamboo, dependence is highest in **Madhya Pradesh**.

14.4. Major Information from India State of Forest Report 2019 (ISFR 2019)

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14.4.1. Forest Cover

- **Forest cover** includes **all tree patches** which have
  - ✓ **canopy density more than 10%** and
  - ✓ **area of 1 ha or more** in size,
  - ✓ **irrespective of their legal status** and **species composition**.

Class	Description
Very Dense Forest	All lands with tree canopy density of 70% and above.
Moderately Dense Forest	All lands with tree canopy density of 40% and more but less than 70%.
Open Forest	All lands with tree canopy density of 10% and more but less than 40%.
Scrub	Forest with canopy density less than **10%.**
Non-forest	Lands not included in any of the above classes. (Includes water bodies)

Forest Cover of India

Class	Area (sq km)	% of GA
Very Dense Forest	**99,278**	**3.02**
Moderately Dense Forest	3,08,472	**9.39**
Open Forest	3,04,499	**9.26**
Total Forest Cover	**7,12,249**	**21.67**
Scrub	46,297	1.41
Non-Forest	**25,28,923**	**76.92**
Total Geographical Area	32,87,469	100.00

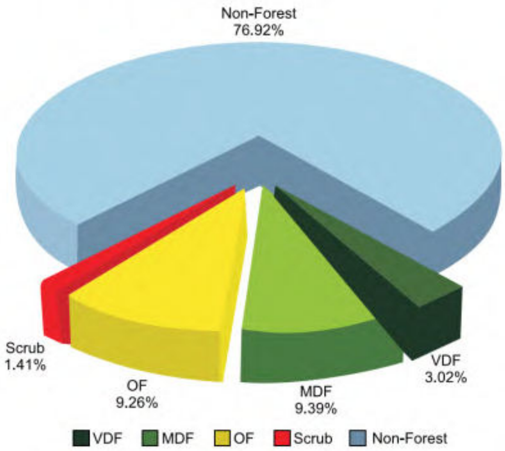
Very Dense Forest

Moderately Dense Forest

Open Forest

Scrub

Pie-chart showing Forest Cover of India



Forest Cover in the States/UTs in India

	State/UT	2019 Forest Cover in sq km				% of GA	% Change	Scrub
		VDF	MDF	OF	Total			
1	Andhra Pradesh	1,994	13,938	13,205	29,137	17.88	3.52	8255
2	**Arunachal Pradesh**	21,095	30,557	15,036	**66,688**	**79.63**	-0.41 ↓	229
3	**Assam**	2,795	10,279	15,253	28,327	36.11	0.79	173
4	Bihar	333	3,280	3,693	7,306	7.76	0.1	250
5	**Chhattisgarh**	7,068	32,198	16,345	55,611	41.13	0.12	610
6	Delhi	7	56	132	195	13.18	1.57	0.3

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7	Goa	538	576	1,123	2,237	**60.43**	0.36	0
8	Gujarat	378	5,092	9,387	14,857	7.57	0.68	2994
9	Haryana	28	451	1,123	1,602	3.62	0.88	154
10	Himachal Pradesh	3,113	7,126	5,195	15,434	27.72	2.21	315
11	UT of J&K	4,203	7,952	8,967	21,122	39.66	1.68	250
	UT of Ladakh	78	660	1,752	2,490	1.47	0.93	298
	J&K Total	4,281	8,612	10,719	23,612	10.62	1.6	548
12	Jharkhand	2,603	9,687	11,321	23,611	29.62	0.25	688
13	**Karnataka**	4,501	21,048	13,026	38,575	20.11	2.73	4484
14	Kerala	1,935	9,508	9,701	21,144	54.42	4.05	13
15	**Madhya Pradesh**	6,676	34,341	36,465	**77,482**	25.14	0.09	6002
16	**Maharashtra**	8,721	20,572	21,485	**50,778**	16.5	0.19	4256
17	**Manipur**	905	6,386	9,556	16,847	**75.46**	-2.88 ↓	1181
18	**Meghalaya**	489	9,267	7,363	17,119	**76.33**	-0.16 ↓	600
19	**Mizoram**	157	5,801	12,048	18,006	**85.41**	-0.99 ↓	1
20	**Nagaland**	1,273	4,534	6,679	12,486	**75.31**	-0.02 ↓	635
21	**Odisha**	6,970	21,552	23,097	**51,619**	33.15	0.53	4327
22	Punjab	8	801	1,040	1,849	3.67	0.65	33
23	Rajasthan	78	4,342	12,210	16,630	4.86	0.35	4760
24	**Sikkim**	1,102	1,552	688	3,342	47.1	-0.06 ↓	307
25	Tamil Nadu	3,605	11,030	11,729	26,364	20.27	0.32	715
26	Telangana	1,608	8,787	10,187	20,582	18.36	0.8	3615
27	Tripura	654	5,236	1,836	7,726	**73.68**	0	29
28	Uttar Pradesh	2,617	4,080	8,109	14,806	6.15	0.87	587
29	Uttarakhand	5,047	12,805	6,451	24,303	45.44	0.03	383
30	West Bengal	3,019	4,160	9,723	16,902	19.04	0.33	146
31	A&N Islands	5,678	684	381	6,743	**81.74**	0.01	1
32	Chandigarh	1	14	6	22	19.32	2.18	0.1
33	Dadra & Nagar Haveli	0	80	127	207	42.16	0	5
34	Daman & Diu	1	6	13	20	18.46	0	0.19
35	Lakshadweep	0	16	11	27	**90.33**	0	0
36	**Puducherry**	0	18	35	52	10.7	-2.35 ↓	0
Total		99,278	3,08,472	3,04,499	**7,12,249**	**21.67**	0.56	46297

- In terms of **% of GA**, the top five States are:
  1. **Mizoram (85.41%)**,
  2. **Arunachal Pradesh (79.63%)**,
  3. **Meghalaya (76.33%)**,
  4. **Manipur (75.46%) and**
  5. **Nagaland (75.31%).**

Change in forest cover

- Although most of the RFA has vegetation cover, yet **there are areas with density less than 10% within it**.
- On the other hand, there are **areas outside the RFA with tree stands of more than 10% canopy density** & **size 1 ha or more**, such areas also constitute **forest cover** under FSI's forest cover assessment.
- Therefore, the **changes** taking place in the **forest cover** is **not necessarily due to changes within the recorded forest areas (RFA)** but also **because of changes outside recorded forest area**.

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- **Note: Forest Cover (canopy density > 10% + more than 1 ha)** & **Recorded Forest Area (areas recorded as 'Forests' in government records) are different**
- **Recorded Forest Area/Forest Area** consists of **reserved Forests (RF)** & **Protected Forests (PF)** constituted under Indian Forest Act, 1927.

Q. Consider the following states :

1. Chhattisgarh
2. Madhya Pradesh
3. Maharashtra
4. Odisha

With reference to the states mentioned above, in terms of percentage of forest cover to the total area of State, which one of the following is the correct ascending order?

a) 2-3-1-4
b) 2-3-4-1
c) 3-2-4-1
d) 3-2-1-4

Answer: c) 3-2-4-1

Top 10 States with largest forest cover

Top 10 States with largest forest cover		
Rank	**State**	**Forest Cover in sq km**
1	**Madhya Pradesh**	**77,482**
2	**Arunachal Pradesh**	**66,688**
3	**Chhattisgarh**	**55,611**
4	**Odisha**	51,619
5	**Maharashtra**	50,778
6	Karnataka	38,575
7	Andhra Pradesh	29,137
8	Assam	28,327
9	Tamil Nadu	26,364
10	Uttarakhand	24,303

Criticism of the definition of 'Forest Cover'

- **A rubber plantation of 1 ha or more can be considered as a forest** under this definition.
- This gives a **false impression** of the state of forests in India as the **ecological importance** of rubber plantations (or for that matter any plantation) is well below that of a natural forest.
- Unlike the roots of trees in a natural forest, the **roots of plantation crops don't run deep**.
- Hence, they **cannot hold the soil tight** which means replacing natural forests with plantation tress like rubber, palm, etc. **can increase the frequency of occurrence and scale of landslides (slope failure)**.
- Massive landslides occurring in **Western Ghats** in recent times are said to be due to replacement of natural forest by plantation agriculture. **(Remember the landslides in Kerala in 2018? Plantation crops!)**
- Plantations **cannot retain moisture** or supporting wildlife the way natural forests do.
- Also, the **carbon stock in plantations is far below than that of a natural forest** of comparable size.

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14.4.2. Recorded Forest Area (RFA)

- **Recorded forest areas** largely consist of **Reserved Forests (RF)** and **Protected Forests (PF)**, which have been constituted under the provisions of **Indian Forest Act 1927** or its counterpart State Acts.
- RFA gives **extent of forest in terms of legal status** or definition of land as 'forest' **irrespective of actual forest canopy cover on the ground**.
- That is, the term 'Recorded Forest Area' is used for **all such lands** which have been **notified as forest** under **any Government Act or Rules** or **recorded as 'forest' in the Government records**.
- **Recorded forest area (RFA) may or may not have forest cover!**
- Forest cover & recorded forest area overlap with each other, but they are not coterminous with each other.
- FSI obtains boundaries of recorded forest areas from the **State Forest Departments (SFD)** as the **SFDs are the custodians of the RFAs**.

Deemed Forests

- **Deemed forests**, which **comprise about 1% of India's forest land**, are a controversial subject as they refer to **land tracts that appear to be a "forest" but have not been notified so by the government**.
- The freedom to define which tracts of forest qualify as **forest (RFA)** has been the **prerogative of States** since 1996.
- **However**, this only applies to forest land that has **not already been historically classified as "forest"** in revenue records or **categorised so by the government as "protected" or "reserve forest"**.
- The **Forest Advisory Committee**, the apex body of the Centre **that deliberates on granting permission to industry to fell forests** said "... States, having well-established Forest Departments should frame criteria for their forests... criteria so finalised by a State need not be subject to approval by the Ministry".

Recorded Forest Areas (RFAs) in States and UTs

GA: Geographical Area; area in sq km

S.No.	State/ UT	GA	RFA (in different categories)			Total RFA (2019)	% of GA
			RF	PF	Unclassed		
1.	Andhra Pradesh	162,968	31,959	5,069	230	37,258	22.86
2.	Arunachal Pradesh	83,743	10,589	9,779	31,039	51,407	61.39
3.	Assam	78,438	17,864	0	8,968	26,832	34.21
4.	Bihar	94,163	693	6,183	1	6,877	7.30
5.	Chhattisgarh	135,192	25,782	24,036	9,954	59,772	44.21
6.	Delhi	1,483	78	24	0	102	6.88
7.	Goa	3,702	253	0	972	1,225	33.09
8.	Gujarat	196,244	14,373	2,886	4,388	21,647	11.03
9.	Haryana	44,212	249	1,158	152	1,559	3.53
10.	Himachal Pradesh	55,673	1,898	33,130	2,005	37,033	66.52
11.	Jammu & Kashmir#	222,236	17,643	2,551	36	20,230	9.10
12.	Jharkhand	79,716	4,387	19,185	33	23,605	29.61
13.	Karnataka	191,791	28,690	3,931	5,663	38,284	19.96
14.	Kerala	38,852	11,309	0	0	11,309	29.11
15.	**Madhya Pradesh**	308,252	61,886	31,098	1,705	**94,689**	30.72
16.	**Maharashtra**	307,713	49,546	6,733	5,300	**61,579**	20.01
17.	**Manipur**	22,327	1,467	4,171	11,780	17,418	**78.01**

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18.	Meghalaya	22,429	1,113	12	8,371	9,496	42.34
19.	Mizoram	21,081	4,483	0	1,158	5,641	26.76
20.	Nagaland	16,579	234	0	8,389	8,623	52.01
21.	**Odisha**	155,707	36,049	25,133	22	**61,204**	39.31
22.	Punjab	50,362	44	1,137	1,903	3,084	6.12
23.	Rajasthan	342,239	12,475	18,217	2,045	32,737	9.57
24.	**Sikkim**	7,096	5,452	389	0	5,841	**82.31**
25.	Tamil Nadu	130,060	20,293	1,782	802	22,877	17.59
26.	Telangana	112,077	20,353	5,939	612	26,904	24.00
27.	Tripura	10,486	4,175	2	2,117	6,294	60.02
28.	Uttar Pradesh	240,928	12,071	1,157	3,354	16,582	6.88
29.	Uttarakhand	53,483	26,547	9,885	1,568	38,000	71.05
30.	West Bengal	88,752	7,054	3,772	1,053	11,879	13.38
31.	**A&N Islands**	8,249	5,613	1,558	0	7,171	**86.93**
32.	Chandigarh	114	32	0	3	35	30.70
33.	Dadra & Nagar Haveli	491	199	5	0	204	41.55
34.	Daman & Diu	111	0	0	8	8	7.21
35.	Lakshadweep	30	0	0	0	0	0.00
36.	Puducherry	490	0	2	11	13	2.65
Total		3,287,469	434,853	218,924	113,642	767,419	23.34

Top 5 States with largest RFA			Top 4 States with largest RFA as a % of GA		
Rank	**State**	**Total RFA**	**Rank**	**State**	**% of GA**
1	**Madhya Pradesh**	94689	UT	**A&N Islands**	**86.93**
2	**Maharashtra**	61579	1	**Sikkim**	**82.31**
3	**Odisha**	61204	2	**Manipur**	78.01
4	**Chhattisgarh**	59772	3	**Uttarakhand**	71.05
5	**Arunachal Pradesh**	51407	4	**Himachal Pradesh**	66.52

- Madhya Pradesh, Maharashtra and Odisha are the states with the highest area of reserved forests.
- Himachal Pradesh, Madhya Pradesh and Odisha are the states with the highest area of protected forests.

Criticism of FSI's approach

- **Doubts** have been raised over **India's claims that its forest cover has been increasing steadily** for years.
- Forest governance in India is so centralised in the hands of governments that its **reports don't reveal the actual truth** about forests in India.

Positives are exaggerated whereas as negatives are suppressed

- The claims of increase in forest cover doesn't reflect the ground reality as the **land acquired for compensatory afforestation is included** in the quantitative accounting of forests **without taking into consideration the loss or diversion of forest land** for mining & other infrastructure projects.

Not enough tree cover but still a forest! Forest on paper!

- ISFR data doesn't explain why **30% of the recorded forest area (2,15,000 sq. km)** has **no forest cover!**
- Such data is crucial to evaluate the effect of state development policies on forest loss and degradation.

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Anything green is a forest?

- The ISFR methodology relies primarily on **remote-sensing techniques** that can pick **anything that is green and of a certain scale on its radar**. This is used to generate data on the extent of 'green cover'.
- For years, foresters and ecologists have said that this report **does not distinguish between natural forests, commercial plantations, orchards and bamboo groves** while enumerating forests.
- According to them, areas with **'tree stands' of over 10% canopy cover** are counted as forests, **irrespective of whether they function ecologically as forests or not**.

14.4.3. Tree Cover

- Tree cover includes **all patches of trees occurring outside RFA** which are of **size less than 1 ha**.
- Forest cover and tree cover put together is called **Forest & Tree Cover**.
- **Forest & Tree Cover is the parameter for monitoring progress** against the **National Forest Policy goal of 33%** of the country's geographical area under it.
- The total tree cover of the country has been estimated 95,027 sq km.
- There is an **increase** of 1,212 sq km in the extent of tree cover as compared to the 2017 assessment.
- State having maximum tree cover is **Maharashtra** (10,806 sq km) followed by **Madhya Pradesh** (8,339 sq km), **Rajasthan** (8,112 sq km) and Jammu & Kashmir (7,944 sq km).
- Considering the percentage of geographical area of State/UTs, the **Union Territory of Chandigarh** shows highest percentage of tree cover (22.34%) followed by Delhi (8.73%), Kerala (7.56%), and Goa (7.34%).

14.4.4. Tress Outside Forests (TOF)

- TOF refers to **all trees outside RFA irrespective of patch size** which **could also be larger than 1 ha**.
- Thus, **tree cover is a subset of TOF**.
- **Maharashtra** is having largest extent of TOF in the country, followed by **Odisha** and Karnataka.
- In terms of percentage of geographical area, the State of **Kerala** has highest percentage of TOF, followed by Goa and Nagaland.

14.4.5. Forest and Tree cover of India in 2019

GA: Geographical Area

Class	Area (sq km)	% of GA
Forest Cover		
1. Very Dense Forest	**99,278**	**3.02**
2. Moderately Dense Forest	**3,08,472**	**9.38**
3. Open Forest	**3,04,499**	**9.26**
Total Forest Cover (Includes Mangroves)	**7,12,249**	**21.67**
Tree Cover	**95,027**	**2.89**
Total Forest and Tree Cover	**8,07,276**	**24.56**
Scrub	46,297	1.41
Non-Forest (includes Tree Cover)	**25,28,923**	**76.92**
Total Geographic Area	32,87,469	100.00

14.4.6. Forest resources in the world

- **Global Forest Resource Assessment (FRA)** done by **FAO** once in **five years** provides information about the forest resources of almost all the countries in the world.

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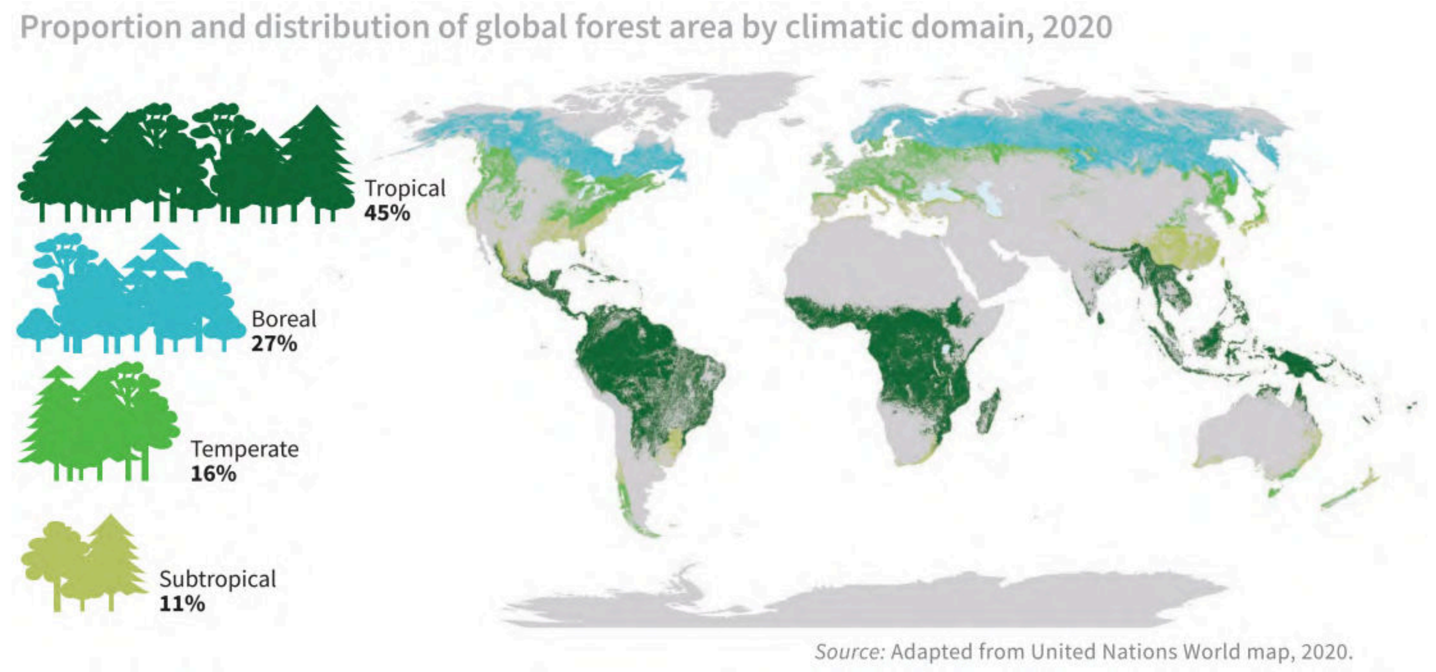
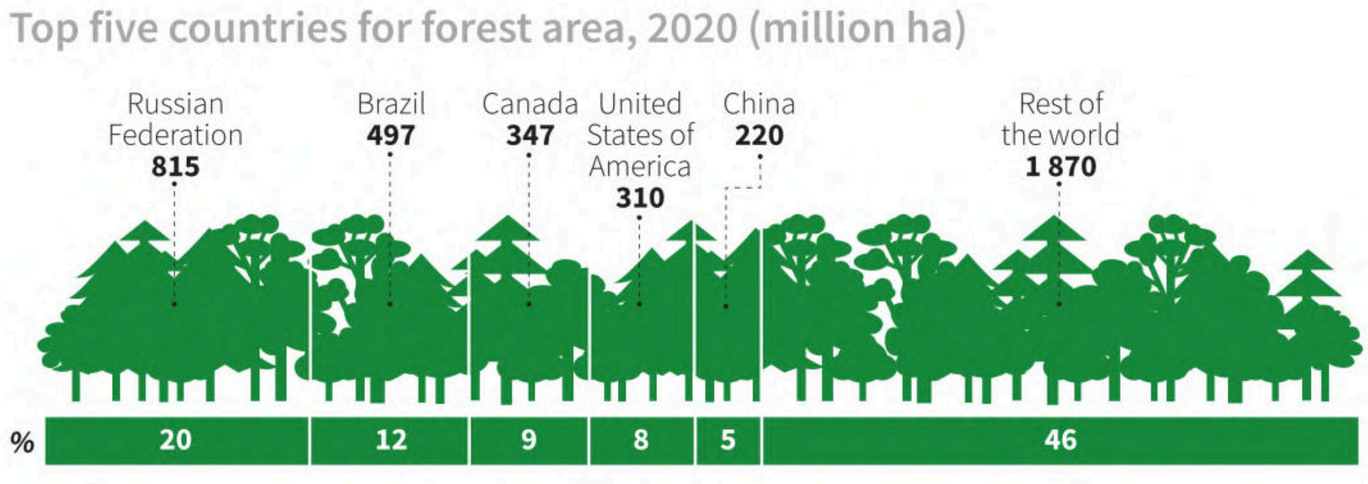
- The latest report of GFRA has been released by FAO in the year **2020**.



Tropical > Boreal > Temperate > Subtropical



14.4.7. Sustainable Development Goals and ISFR 2019

	14.2.1: Percentage change in area under mangroves (2 years) 14.5.2: Percentage change in area under Mangroves (Annual)
	15.1.1: Forest area as a proportion of total land area 15.1.2: Percentage of Tree Outside Forest (TOF) in total forest cover 15.2.1: Percentage change in Forest area coverage 15.2.3: Total tree cover achieved outside forest area 15.3.2: Increasing Tree/Forest cover in degraded area 15.4.1: Increase in forest/vegetative cover in mountain areas

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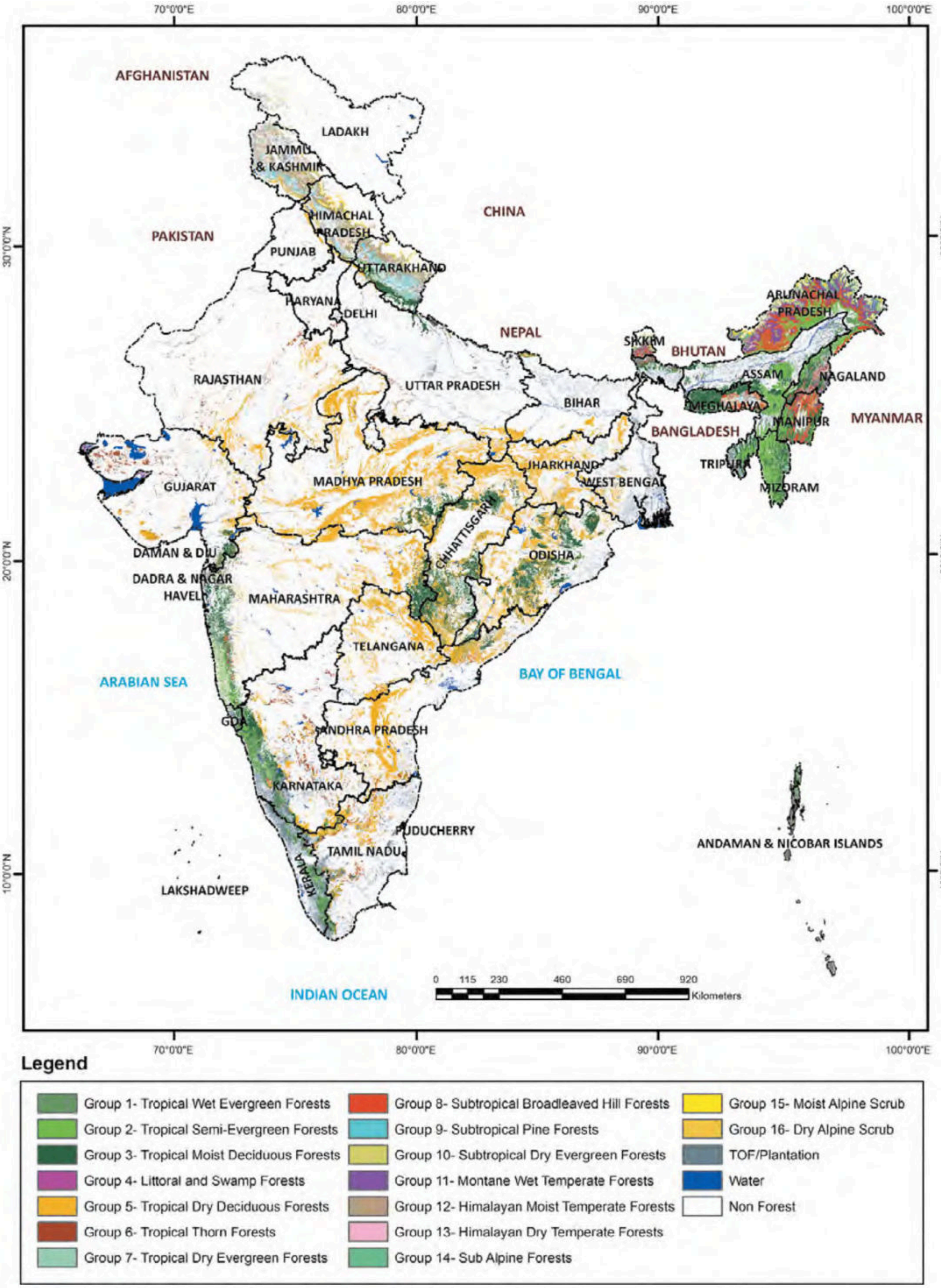

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- The Sustainable Development Goals (SDGs) consists of 17 goals and 169 targets (UNDP, 2016).
- Most of the goals and targets in the SDGs have environmental dimension and 25 specific targets are identified for priority implementation by the Ministry of Environment, Forest and Climate Change.

14.4.8. Forest Types and Biodiversity

- H.G. Champion first enunciated a classification system for forests of undivided India in 1935.
- **S.K. Seth** subsequently joined Champion in refining the earlier work in 1968.
- Subsequently, their system became the standard in forest type classification in the country.
- Their classification of forest types is based on the premise that a **forest type could be treated as a distinct ecosystem**; many preceding classification systems are based on **climate, soil or vegetation** alone.
- It is a three-tier system of classification: **six climate based major groups** were sub-divided into **16 precipitation and temperature range-based type groups**.
- **Maximum tree diversity** has been found in **Tropical wet evergreen** and **semi evergreen forests of Western Ghats** (Tamil Nadu, Kerala and Karnataka) followed by North Eastern states.
- **Low tree diversity** has been noticed in the **Sub Tropical dry evergreen forests** of Jammu and Kashmir and forest deficit States like Punjab, Haryana and Rajasthan.
- **Karnataka has** maximum species richness for **trees**.
- **Arunachal Pradesh** has maximum species richness for **shrubs**.
- **Jammu & Kashmir** has maximum species richness for **herbs**.
- **Arunachal Pradesh** has the maximum richness of **species** when **all the three types of plants** are considered, followed by **Tamil Nadu** and **Karnataka**.

Forest area for top 5 countries in 2015

M ha: Million hectares; 100 ha = 1 sq km

	Country	Forest area (M ha) (2015)	Forest area (M ha) 2020	% of country area	% global forest area
1.	**Russian Federation**	814	815	48	20
2.	**Brazil**	493	497 ↑	58	12
3.	**Canada**	347	347	35	9
4.	**USA**	310	310	32	8
5.	**China**	208	220 ↑	22	5

⇨ **Brazil saw an increase in forest area** despite the unprecedented destruction of Amazon forests. Great!

Area under different Forest Type Groups of India

S.No.	Type Group	Area in sq km	% of Grand Total
1.	Group1: **Tropical Wet Evergreen Forests**	20,054	2.61
2.	Group2: **Tropical Semi Evergreen Forests**	71,171	**9.27**
3.	Group3: **Tropical Moist Deciduous Forests**	1,35,492	**17.65**
4.	Group4: Littoral & Swamp Forests	5,596	0.73
5.	Group5: **Tropical Dry Deciduous Forests**	3,13,617	**40.86**
6.	Group6: Tropical Thorn Forests	20,877	2.72
7.	Group7: Tropical Dry Evergreen Forests	937	0.12
8.	Group8: Subtropical Broadleaved Hill Forests	32,706	4.26

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9.	Group9: Subtropical Pine Forests	18,102	2.36
10.	Group10: Subtropical Dry evergreen Forests	180	0.02
11.	Group11: Montane Wet Temperate Forests	20,435	2.66
12.	Group12: Himalayan Moist Temperate Forests	25,743	3.35
13.	Group13: Himalayan Dry Temperate Forests	5,627	0.73
14.	Group14: Sub Alpine Forests	14,995	1.96
15.	Group15: Moist Alpine Scrub	959	0.13
16.	Group16: Dry Alpine Scrub	2,922	0.38
17.	Plantation/TOF	64,839	8.45
Total (Forest Cover + Scrub)		7,54,252	98.26
18.	Grass land in different forest type groups	13,329	1.74
Grand Total		7,67,581	100.00
In the decreasing order of Area			
1	**Group5: Tropical Dry Deciduous Forests**	3,13,617	**40.86**
2	**Group3: Tropical Moist Deciduous Forests**	1,35,492	**17.65**
3	**Group2: Tropical Semi Evergreen Forests**	71,171	**9.27**
4	Group8: **Subtropical Broadleaved Hill Forests**	32,706	4.26
5	Group12: **Himalayan Moist Temperate Forests**	25,743	3.35
6	Group6: **Tropical Thorn Forests**	20,877	2.72
7	Group11: **Montane Wet Temperate Forests**	20,435	2.66
8	Group1: **Tropical Wet Evergreen Forests**	20,054	**2.61**
9	Group9: Subtropical Pine Forests	18,102	2.36
10	Group14: Sub Alpine Forests	14,995	1.96
11	Group13: Himalayan Dry Temperate Forests	5,627	0.73
12	Group4: Littoral & Swamp Forests	5,596	0.73
13	Group16: Dry Alpine Scrub	2,922	0.38
14	Group15: Moist Alpine Scrub	959	0.13
15	Group7: Tropical Dry Evergreen Forests	937	0.12
16	Group10: Subtropical Dry evergreen Forests	180	0.02

14.4.9. Fire Proneness categories and criteria

Category	Range
Extremely fire prone forest area	Average frequency of forest fires >4 in a grid per year
Very highly fire prone forest area	Average frequency of forest fires (> 2 and <4) in a grid per year
Highly fire prone forest area	Average frequency of forest fires (> 1 and <2) in grid per year
Moderately fire prone forest area	Average frequency of forest fires (> 0.5 and <1) in grid per year
Less fire prone forest area	Average frequency of forest fires (< 0.5) in grid per year

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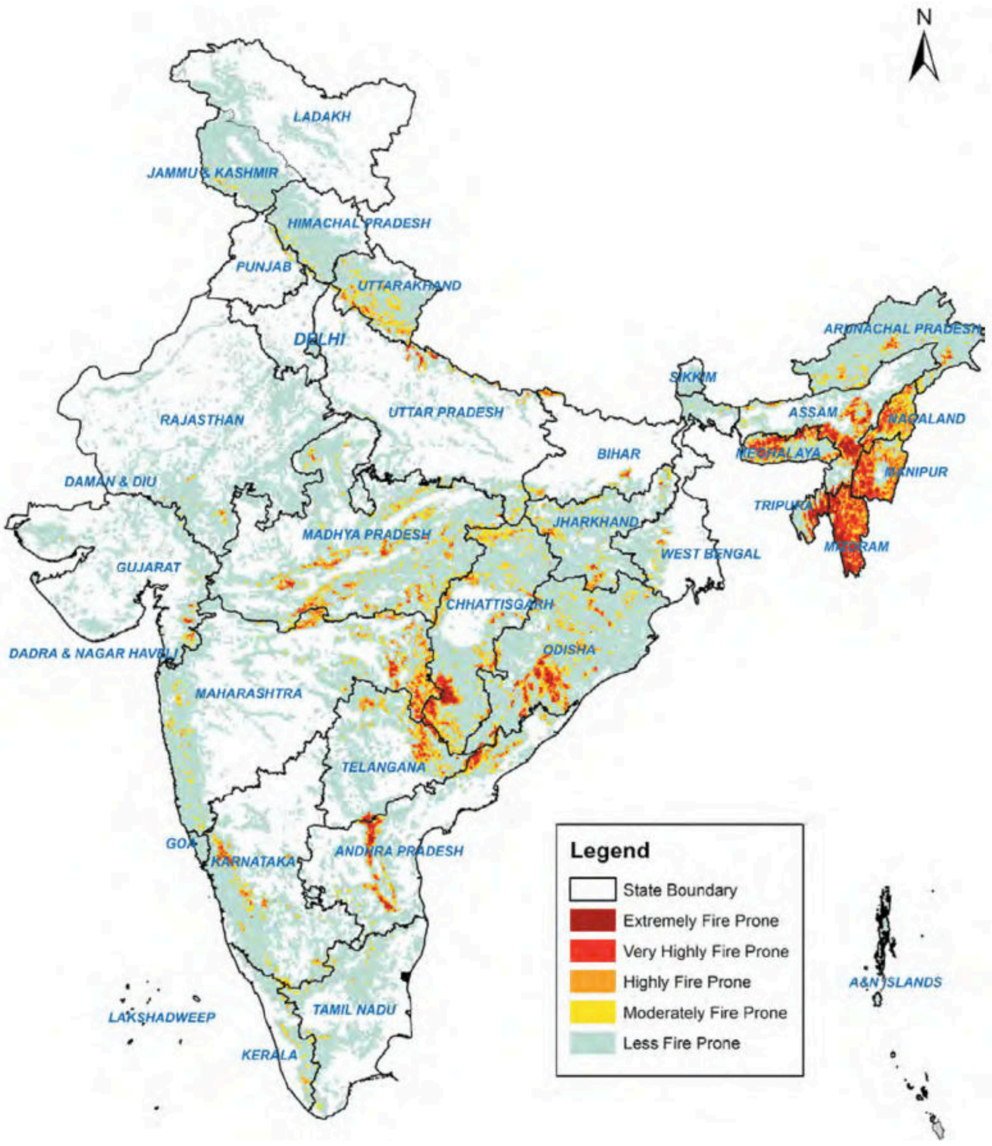

14.4.10. National Forest Inventory

- The primary objective of the forest inventory is to assess growing stock of trees, number of trees, bamboo, soil carbon, occurrence of Non-Timber Forest Products (NTFP), invasive species, etc.

Stock

- Growing stock is an indicator of forest productivity.
- The growing stock per hectare at the national level has been estimated as **55.69 cum**.
- The highest per hectare growing stock in forest has been found in **J&K** followed by **Kerala**.
- In respect of total growing stock **Arunachal Pradesh** has maximum growing stock in forests followed by Uttarakhand, Chhattisgarh and Himachal Pradesh.

Bamboo Resources of the Country

- Bamboos are one of the fastest growing perennial plants in the world.
- Bamboo culms grow from the dense root **rhizome** system.
- Bamboo is capable of thriving in an extreme range of climatic and edaphic (soil) conditions.
- They are found in the in the **tropical, sub-tropical and mild temperate regions** of the world.

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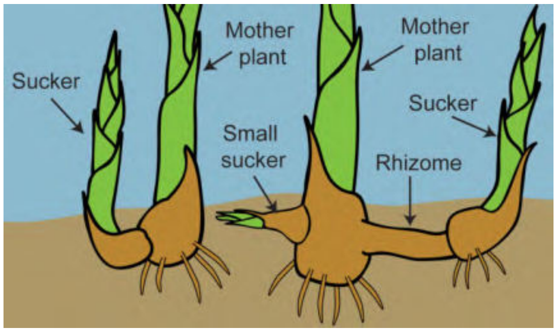
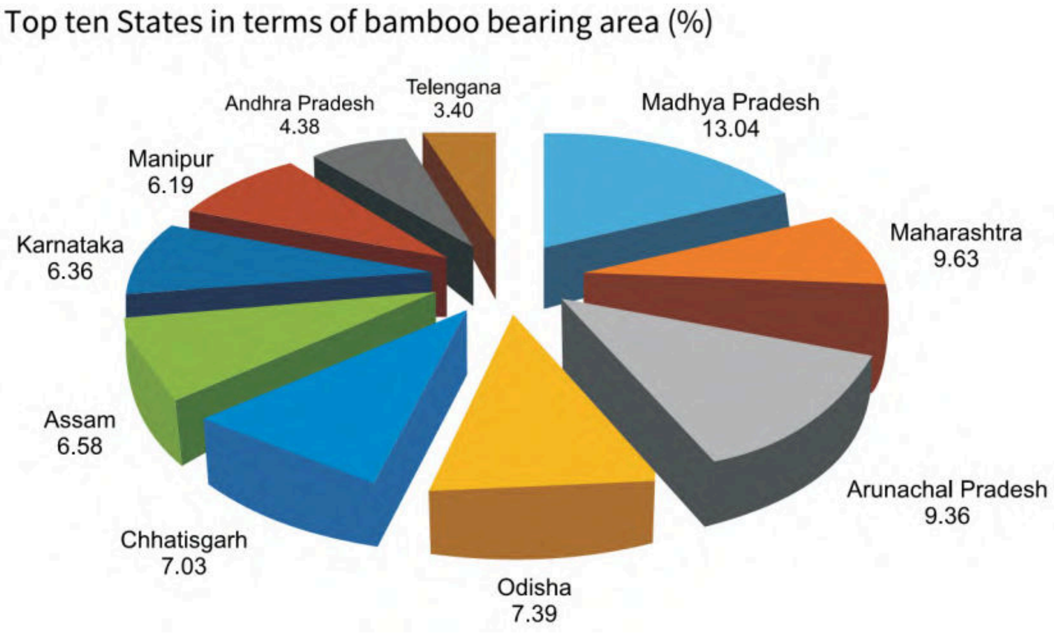


- Distribution of bamboo is uneven and largely depends on climatic factors, altitude, and soil conditions.
- Bamboo plays an important role in **carbon sequestration**, **biodiversity** and **soil moisture conservation**.
- Bamboos are naturally in abundance in **East and Southeast Asia and Islands of Pacific & Indian oceans**.
- Large tracts of natural bamboo forest are found in Asian countries between **15° and 25° N latitudes**.
- In India, bamboo grows naturally almost throughout the country **except in Kashmir region**.
- Bamboos occur in abundance in the **deciduous and semi-evergreen forests of the North-eastern region** and the **tropical moist deciduous forests of Northern and Southern India**.
- The **North Eastern States & West Bengal** account for more than **50% of the India's bamboo resources**.
- Other bamboo rich areas of the country are the **Andaman & Nicobar Islands, Chhattisgarh, Madhya Pradesh** and the **Western Ghats**.



Economic Importance of Bamboo

- Bamboos are an important component of the **subsistence economy** in providing livelihood to the tribals.
- It is an important non-wood forest product used in making normal and fine quality paper, furniture, flooring, handi-crafts, walking sticks, fishing poles etc.
- It is estimated that in India there are about 2 million traditional artisans whose livelihood depends almost entirely on harvesting, processing, and selling of bamboo products such as baskets, mats, handicrafts etc.
- Young bamboo shoots are used as **vegetables** in many cuisines.
- Bamboo stems can be split up for use as pipes in channelling water.
- Raw leaves of many bamboo species are a source of fodder for cattle.

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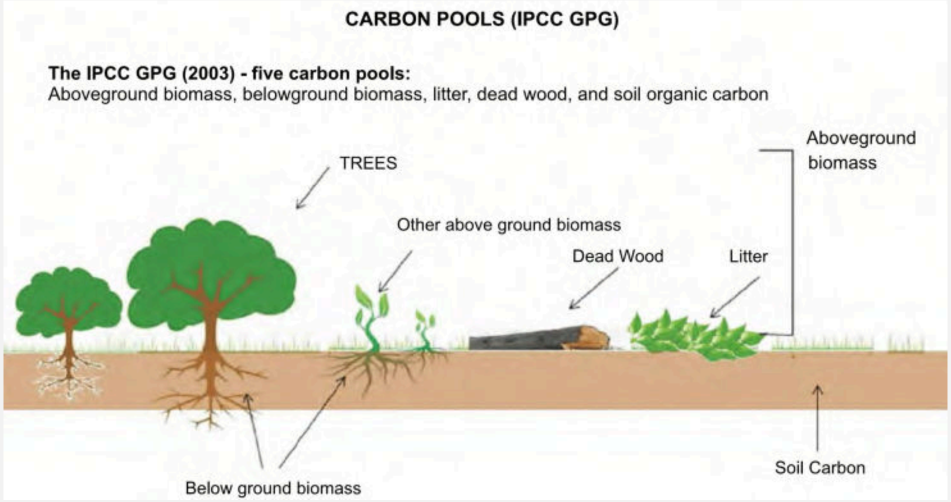
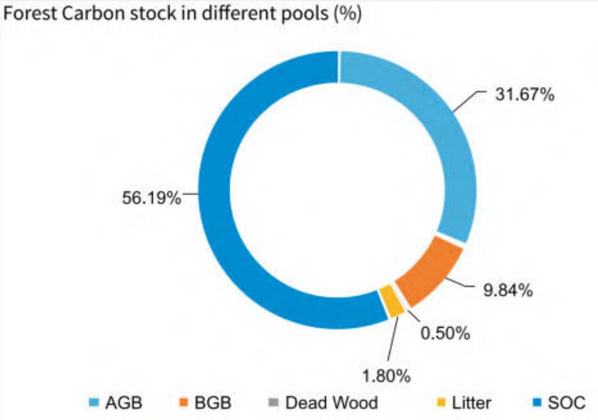
- The largest stems of bamboo are used as planks for houses and rafts, while both large and small stems are lashed together to form the scaffoldings at construction sites.
- Bamboo is therefore, called as **green gold**, **poor man's timber**, **cradle to coffin timber** etc.

Carbon Stock in India's Forests

World's Forest Carbon Stocks

- The **world's forests & forest soils** currently store more than **one trillion tons of carbon** which is nearly **1.3 times larger** than the **carbon stored in fossil fuel reserves** (estimated at about **800 Gt**) and **more** than the **carbon added to the atmosphere because of human activities since 1870** (about **600 Gt**).
- It has been estimated that since 1750, **forests** have been responsible for about **half of the carbon emissions naturally sequestered from the atmosphere**; **the rest has been absorbed by the oceans**.
- Forests store an estimated **296 Gt of carbon in both above and below ground biomass which contains almost half of the total carbon stored in forests**, the other half being the **soil organic carbon**.
- Globally, over the last 25 years, the carbon stock in forest biomass has **decreased** by almost 17.4 Gt, equivalent to a reduction of 697 million tonnes per year or about 2.5 Gt of carbon dioxide equivalent.





- India is committed to meet its commitments under the **Nationally Determined Contributions** (NDC) made to the international community under the **Paris Agreement (2015)**.
- According to the forestry target under NDC, India has committed to create **additional carbon sink of 2.5 to 3.0 billion tonnes of CO_2 equivalent** through **additional forest and tree cover** by **2030**.
- The commitment is backed with the fact that the **emission intensity** of India's Gross Domestic Product (GDP) has **reduced** by 21% over the period of 2005-2014.

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- Emissions from India stood at **2.6 billion tonnes CO_2 equivalent** in **2014**.
- The **energy sector accounted for 73%**, Industrial Processes 8%, **agriculture 16%** and waste sector 3% whereas the Land Use, Land Use Change and Forestry sector offset about 12% of India's total emissions.
- **Arunachal Pradesh** has maximum carbon stock of 1,051.32 million tonnes followed by **Madhya Pradesh** (588.73 million tonnes), Chhattisgarh (480.25 million tonnes) and Maharashtra (440.51 million tonnes).
- **Sikkim** has maximum per hectare carbon stock of 171.04 tonnes/ha, followed by **Andaman & Nicobar Islands** (167.09 tonnes/ha), J&K (165.25 tonnes/ha) and Himachal Pradesh (163.51 tonnes/ha).
- At the national level **32% of carbon stock is in AGB** whereas about **56% in SOC**.

Pools		Description
Living Biomass	Above ground biomass (AGB)	All living biomass above the soil.
	Below ground biomass	All living biomass of live roots.
Dead Organic Matter	Dead wood	Includes all non-living woody biomass not contained in the litter.
	Litter	Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country, lying dead, in various states of decomposition.
Soil	Soil organic matter	Includes **organic carbon in mineral and organic soils** (including peat) to a specific depth.

- In all the NE states it is observed that SOC is almost double the carbon in AGB.
- The carbon stock in India's forests for 2019 has been estimated **7,124.6 million tonnes**.
- There is an **increase** of 42.6 million tonnes of forest carbon stock as compared to 2017 estimates.
- **Soil organic carbon** is the largest pool of forest carbon accounting for (**56.19 %**) followed by **AGB (31.67 %)**, **BGB (9.84 %)**, Litter (1.80 %) and dead wood (0.50 %).
- A comparison between the NDC target and the projection for 2030 in business as usual shows a short fall of 0.25 billion tonnes and 0.75 billion tonnes of CO_2 equivalent against the target of 2.5-3.0 billion tonnes.
- NDC target can be achieved by activities such as restoration of open forests and afforestation on available lands like wastelands, agro-forestry, along national & State highways, railway siding, urban landscapes etc.
- **Restoration of open forests is the most cost-effective strategy to achieve the NDC target** and at the same time it holds large potential of creating additional carbon sink.
- Above 70% of forest cover in India falls in **Tropical Semi-Evergreen, Tropical Moist Deciduous and Tropical Dry Deciduous Forest Type**.
- More than 30% areas have this Forest Types fall in the category of **Open Forest**, which need to be improved in order to achieve NDC targets.
- Among these forest types **Tropical Dry Deciduous** and **Tropical Moist Dry Deciduous** may be taken up.

Q. Examine the status of forest resources of India and its resultant impact on climate change. (Mains 2020 – 250words)

Forest Type wise Carbon Stock at the National level in different carbon pools with per ha stock given in tonnes in parenthesis ('000 tonnes)

	Forest Type Stratum	Area in sq km	Carbon Stock
1.	**Tropical Dry Deciduous Forests**	290724	21,58,122 (74.23)
2.	**Tropical Moist Deciduous Forests**	135834	13,19,570 (97.15)
3.	**Tropical Semievergreen Forests**	71807	7,18,993 (100.13)
4.	Himalayan Moist Temperate Forests	26184	5,67,795 (216.85)

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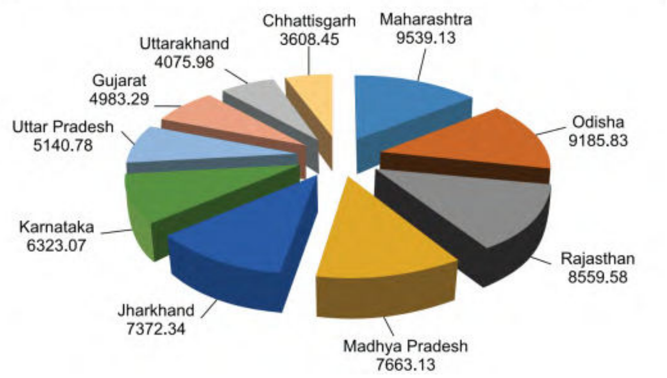
5.	Subtropical Broad leaved Hill Forests	31993	4,43,900 (138.75)
6.	Montane Wet Temperate Forests	20653	3,55,750 (172.25)
7.	Tropical Wet Evergreen Forests	20170	3,44,646 (170.86)
8.	Subtropical Pine Forests	17619	2,25,161 (127.79)
9.	Sub-Alpine Forests	14184	3,02,337 (213.15)
10.	Himalayan Dry Temperate Forests	5565	1,21,267 (217.88)
11.	Tropical Thorn Forests	14552	76,638 (52.67)
12.	Littoral and Swamp Forests	5527	55,672 (100.74)
13.	Dry Alpine Scrub	2006	21,533 (107.37)
14.	Moist Alpine Scrub	1975	15,190 (76.9)
15.	Tropical Dry Evergreen Forests	858	7,562 (88.15)
16.	Subtropical Dry Evergreen Forests	184	2,769 (150.58)
17.	Plantation/TOF	52,414	3,87,775 (73.98)
Total		7,12,249	71,24,680 (100.03)

- The maximum carbon stock has been stored in **tropical dry Deciduous forests** (~2.2 m tonnes) followed by **Tropical Moist Deciduous Forest** (~1.3 m tonnes) & **Tropical Semi Evergreen forests** (~0.7 m tonnes).
- The maximum per hectare carbon stock has been stored in **Himalayan Dry Temperate Forests**, Himalayan Moist Temperate Forests and Sub-Alpine Forests.

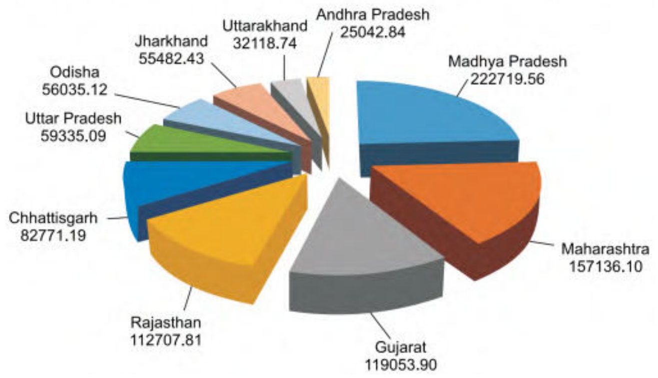
Forests

- As per the Census 2011, there are about 6,50,000 villages in the country, out of which nearly 1,70,000 villages are located in the proximity of forest areas, they are often termed Forest Fringe Villages.
- The population in these villages is dependent on the forests for meeting the needs of fuelwood, fodder, small timber, bamboo and NTFPs.

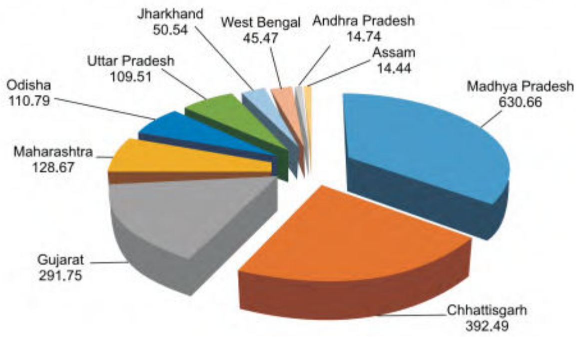
(a) Top 10 states in terms of dependence on forests for fuelwood ('000 tonnes)



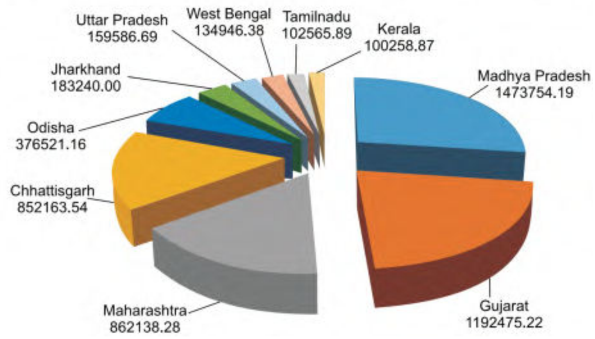
(b) Top 10 states in terms of dependence on forests for fodder ('000 tonnes)



(c) Top 10 states in terms of dependence on forests for bamboo ('000 tonnes)



(d) Top 10 states in terms of dependence on forests for small timber (cum)



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14.5. Global Forest Resources Assessment 2020

- India has ranked 3rd among the top 10 countries that have gained in forest areas in the last decade, according to the latest **Global Forest Resources Assessment (GFRA) 2020**.
- Global Forest Resources Assessment 2020 (FRA 2020) is released by **Food & Agriculture Organization (FAO) of the United Nations.**
- FAO has brought out this comprehensive assessment **every five years** since 1990.

14.5.1. Findings of the Report

- The **Top 3 countries** that have recorded the **maximum average annual net gains in forest area** during 2010–2020 are:
  1. **China**
  2. **Australia**
  3. **India**
- **India accounts for 2% of total global forest area**.
- The Asian continent reported the highest net gain in forest area in 2010–2020.
- India reported **0.38 per cent annual gain in forest**, or 266,000 ha of forest increase every year at an average.

GFRA & India

- The FRA 2020 has credited the government's **Joint Forest Management programme** for the significant increase in community–managed forest areas in the Asian continent.
- The **forest area managed by local, tribal & indigenous communities** in India **increased** from zero in 1990 to about 25 million ha in 2015.
- India has been taking up massive afforestation & plantation schemes.
- During 2010–20, the rate of increase in **naturally regenerating forest** was just **0.38 per cent**.
- India reported the **maximum employment** in the forestry sector in the world.
- Globally, 12.5 million people were employed in the forestry sector.
- India accounted for nearly **50 per cent**.

About FAO

- The Food and Agriculture Organization (FAO) is a **specialized agency** of the United Nations that leads international efforts to **defeat hunger**.
- Goal of FAO is to achieve **food security** for all and make sure that people have regular access to enough high-quality food to lead active, healthy lives.
- With over 194 member states, FAO works in over 130 countries worldwide.
- The FAO is headquartered in **Rome, Italy**.
- It helps governments and development agencies coordinate their activities.

14.6. National Forest Policy of India

- India is one of the few countries which has a forest policy since 1894.
- The policy was revised in 1952 and again in 1988.

14.6.1. National Forest Policy 1998

- The principal aim of 1988 Forest Policy was to ensure **environmental stability & maintenance of ecological balance** including **atmospheric equilibrium**.

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- The derivation of direct economic benefit must be subordinated to this principal aim.

Policy Features & Aims

- It for the first time considered **forest land or land with tree cover as a national asset**.
- Diversion of forest land for any non-forest purpose should be subject to the most careful examination.
- The goal should be to have a minimum of **1/3rd of the total land area under forest or tree cover**.
- Conservation of natural heritage and checking soil erosion and denudation in catchment areas.
- **Checking extension of sand dunes in desert areas of Rajasthan & along coastal tracts**
- Substantially increasing forest/tree cover through massive **afforestation & social forestry programmes**.
- It underscored **symbiotic relationship between tribal people & forests & including tribal people** closely in the protection, regeneration and development of forests.
- Taking steps to meet requirements of fuel, wood, fodder, minor forest produce, soil and timber of rural and tribal populations.
- Increasing productivity of forests to meet the national needs.
- Encouraging efficient utilization of forest produce and optimum substitution of wood.
- Taking steps to **create massive people's movement with involvement of women** to achieve the objectives and minimize pressure on existing forests.
- It provided greater impetus on **Forestry Education & Research**.

14.6.2. Draft National Forest Policy 2018

- **Reverse the degradation of forest**.
- Contribute towards achieving forestry related **Nationally Determined Contribution Targets (NDC's)**.
- Maintenance of the health of forest vegetation and forest soils for augmenting water supplies through **recharge of underground aquifers & regulation of surface water flows**.
- Manage protected areas and other wildlife rich areas with the primary objective of **biodiversity conservation** and for enriching other ecosystem services.
- **Factor green accounting**, **valuation of ecosystem services** and **climate change** concerns adequately into the planning and management of all forests, protected areas and other ecosystems.
- Integrate climate change mitigation and adaptation measures in forest management through the **mechanism of REDD+** so that the impacts of the climate change is minimised.
- Managing and expanding **green spaces in urban and peri-urban areas** to enhance citizens' wellbeing.
- **Sustainable use of Non-Timber Forest Produce (NTFP)** such as medicinal and aromatic plants, oil seeds, resins, wild edibles, fibre, bamboo, grass etc.
- **Credible certification process** to enhance value of forest product harvested sustainably.
- Greater emphasis on protecting **forests of North-East.**
- A **National Board of Forestry (Headed by Environment Minister)** & **State Boards of Forestry (Headed by State Environment Minister)** will be established for ensuring convergence, & conflict resolution.
- Integration and assimilation of **international multilateral agreements & commitments**.
- **Private intervention** for maintaining quality of the forests.

14.7. Afforestation Programmes

- The MoEF is implementing afforestation schemes in the forest areas with **participatory approach**.
- The plantation species under the schemes is selected by the members of **Joint Forest Management Committees (JFMC)** on the basis of their needs, ecological conditions and other factors.

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- The **native forest species** with multiple uses are encouraged for plantation in the forest areas.
- The ministry is implementing three major schemes for development of forest areas:
  1. **National Afforestation Programme (NAP) scheme**
  2. **National Mission for a Green India (GIM) (Green India Mission)**
  3. **Forest Fire Prevention & Management Scheme (FFPM)**
- The **NAP** is being implemented for **afforestation of degraded forest lands**.
- The **GIM** aims at **improving the quality of forest and increase in forest cover**.
- The **FFPM** takes care of **forest fire prevention** and management measures.
- For **scientific management** of forests, the **states** prepare **Working Plan** which highlights various activities to be undertaken in a forest division for effective management of forest which is **approved by MoEF**.
- The funds collected under **Compensatory Afforestation Fund Management and Planning Authority (CAMPA)**, as compensatory levies from states inter-alia, is also used in plantation activity.

14.7.1. National Afforestation Programme (NAP)

- **NAP** aims at **restoration of degraded forests** and develop the forests with **peoples' participation**.
- It aims to support and accelerate the on-going process of devolving forest to the **Joint Forest Management Committees (JFMCs) at the village level**, which are **registered societies**.
- NAP is a **centrally sponsored scheme** which is implemented with the fund sharing pattern of **60: 40 percent between Centre and States** wherein the sharing pattern for **North-eastern and hilly States** is **90:10**.
- NAP is implemented by **three tier institutional setup** through the
  1. **State Forest Development Agency (SFDA)** at the state level,
  2. **Forest Development Agency (FDA)** at the forest division level and
  3. **Joint Forest Management Committees (JFMCs)** at **village level**.

Joint Forest Management (JFM)

- The concept of JFM was introduced by GOI through the **National Forest Policy of 1988**.
- Joint Forest Management (JFM) is a forest management partnership involving the forest departments and **local communities**.
- The communities are required to organize Forest Protection Committee (FPC), village forest committees, village forest conservation and development societies, etc.
- Each of these bodies has an executive committee that manages its day-to-day affairs.
- Woman sub-committee in the **Joint Forest Management Committee (JFMC)** ensures gender balance.
- In return of their services to the forests, the **communities get the benefit of using minor non-timber forest produce**.

Examples of Joint Forest Management (JFM)

- Controlled grazing of cattle by the **Gaddi and Gujjar tribes in the Himalayan states** prevents the widespread growth of wild grass, thus contributing towards conservation of biodiversity.
- **Bishnoi community of Rajasthan and Punjab** play a significant role in the conservation of **Black Buck**.
- **Maldharis**, living in vicinity of Gir National Park, has contributed to the improvement of lion population.

Issues with Joint Forest Management (JFM)

- Implementation of JFM afforestation programmes is expensive (Rs 20,000 per ha).
- Inadequate remuneration for local communities from JFM activities.
- Lack of legal status and financial and executive powers for Forest Protection Committee (FPC).

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- Forest Department in certain States vested with arbitrary powers to dissolve FPCs.
- Absence of participation by women in spite of their formal representation in management committees.
- Inter and intra-community conflicts that hamper FPC functioning.
- Denial of rights on disposal over valuable Non-timber forest product (NTFPs) to local communities.

Social forestry

- Social forestry is the management and protection of forests and **afforestation of barren and deforested lands** with the help of **local communities**.
- The National Commission on Agriculture, GOI, first used the term 'social forestry' in 1976.
- Social forestry was meant to taking the pressure off the forests and making use of unused and fallow land.
- With the introduction of this scheme the government formally recognised the **local communities' rights** to forest resources.

Components of Social Forestry

- **Farm forestry:** commercial and non-commercial farm forestry is being promoted where individual farmers were encouraged to plant trees on their own farmland.
- **Community forestry:** raising of trees on community land by communities for the benefit of the **entire community**. The government has the responsibility of providing seedlings and fertilizer.
- **Extension forestry:** Planting of trees on the sides of roads, canals and railways, along with planting on wastelands is known as 'extension' forestry. Under this project there has been creation a of wood lots in the village common lands, government wastelands and panchayat lands.
- **Agroforestry:** Planting of trees on and around agricultural boundaries, and on marginal, private lands, in combination with agricultural crops is known as agroforestry.

Social forestry suffers from similar issues as those faced by Joint Forest Management.

14.7.2. Compensatory Afforestation (CA)

- Under the **Forest (Conservation) Act, 1980**, whenever forest land is diverted for **non-forestry purposes**,
  - ✓ **an equal area of non-forest land (revenue land)** or
  - ✓ **twice the area of degraded forest land has to be planted over as CA**.
- The process starts with the project proponent identifying land for CA and proposing the same to the **state forest department**.
- If the department approves the proposal, the **project proponent pays for the land** (called **Net Present Value**), which is transferred to the forest department.
- The **forest department then undertakes plantation work on that land**.

Compensatory Afforestation Fund (CAF) Act, 2017

- Until 2019, afforestation was allowed on **degraded forest land only if revenue land was not available**.
- MoEF brought in a notification under CAF, **allowing compensatory afforestation in forestland where crown density is less than 40 per cent**.

Compensatory Afforestation Fund Management and Planning Authority (CAMPA)

- CAMPA is a National Advisory Council under the chairmanship of the Union Minister of Environment.
- CAMPA at the national and state level CAMPAs are meant to promote afforestation and regeneration activities as a way of compensating for forest land diverted to non-forest uses.
- The CAMPA National Advisory Council makes recommendations to State CAMPA.

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- CAMPA and state CAMPA were setup after the intervention of the Supreme Court.
- The Supreme Court has approved the guidelines prepared by the MoEF for **utilizing CAMPA funds by an agency to be constituted in the states** and to be known as The State CAMPA.
- The State CAMPA receives funds collected from user agencies towards compensatory afforestation.

Q. Consider the following statements: (2019)

1) As per law, the Compensatory Afforestation Fund Management and Planning Authority exists at both National and State levels.
2) People's participation is mandatory in the compensatory afforestation programmes carried out under the Compensatory Afforestation Fund Act, 2016.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Explanation:

- The act stresses on participation of people and social audit. However, they are not mandatory.

Issues with the present system of compensatory afforestation (CA)

- Industries have often complained that they find it hard to acquire appropriate non-forest land, which has to be **contiguous to existing forest**.
- Nearly ₹50,000 crore had been **collected by the Centre** over decades, but the funds were lying unspent because states were not spending the money on regrowing forests. The Supreme Court intervened; a new law came about with rules for how this fund was to be administered.
- About ₹47,000 crore had been disbursed to states, but it has **barely led to any rejuvenation of forests**.

Only few species are used in Compensatory Afforestation schemes

- Protecting and regenerating natural forests should comprise a **diverse mix of native tree species** that are more reliable in the long term than raising **monoculture or species-poor plantations**.
- Using satellite data from multiple locations in the Western Ghats, an international team of researchers has shown that **carbon storage was highest in species-rich evergreen forest**.
- The study was done in natural evergreen and deciduous forests, and in teak and eucalyptus plantations.
- The studied **eucalyptus plantations had comparatively lower carbon storage**, while **teak plantations stored nearly as much carbon as deciduous forests**.
- Currently, according to government data, over half of **compensatory afforestation plantations use five species or less**, which is way lower than in natural forests and totally inadequate.
- This is neither good for biodiversity nor for the stability of carbon capture.
- **Grasslands help in carbon capture themselves** and planting few species of trees there can cause more harm than good.

Green Credit Scheme

- The **Forest Advisory Committee (FAC)**, an **apex body under MoEF** tasked with **adjudicating requests** to **raze forest land for commercial ends**, has approved the **Green Credit Scheme** that could allow **"forests" to be traded as a commodity**.

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- It has recommended that **private players be allowed to raise plantations** to be later used towards CA.
- If implemented, it allows the **Forest Department to outsource its responsibilities of reforesting to non-government participating agencies** — private companies, village forest communities, etc.
- After **three years**, they would be **eligible to be considered as compensatory forest** land if they met the Forest Department's criteria.
- The **participating agency will be free to trade its asset**, that is plantation, in parcels, with project proponents who need forest land.
- And the forest land would then be transferred to the **Forest Department** and be recorded as forest land.

FAC's Take

- After a thorough deliberation, **FAC** recommended that such plantations be accepted on **non-forest area**.
- The FAC believes that such a scheme will encourage plantation by individuals outside the traditional forest area and will help in meeting international commitments such as SDGs and NDCs.
- The **Green India Mission** aims to **sequester 2.523 billion tonnes of carbon by 2020-30**, and this involves adding **30 million hectares** in addition to existing forest. Green Credit Scheme could be of help here.

Criticism of the Green Credit Scheme

- Concerns are being raised that the scheme would lead to **privatisation of forests** & give impetus to their destruction.
- If the economic value of these plantations becomes lucrative, it can pose a **serious threat to agricultural land, by diverting the latter for plantations**.
- It does not solve the core problems of compensatory afforestation. Forests are treated as a **mere commodity without any social or ecological character**.
- The plantations will be ready to be traded after **three years**. So, a private company would want to grow **species like eucalyptus (invasive species)** which will **mature quickly** within three years.

14.7.3. Aerial Seeding for Reforestation

- The Delhi High Court asked forest authorities whether "planting of seeds could be done by throwing dart shots containing them from helicopters into forest areas".
- The Forest Department has concluded that such technology need not be employed for places that are easily accessible.

Aerial seeding

- **Aerial seeding (aerial reforestation)** is a reforestation technique wherein seeds or seed balls (**seed bomb** — made up of compost, clay & seeds) are sprayed using aerial devices like helicopters, drones, etc.
- Seeds planted through this procedure **have a success rate of 50%.**

- Aerial seeding can be used to spread grasses and plants to large areas of the land after wildfires.
- Aerial seeding is adopted because it is quicker and more effective than planting manually.
- It also allows access to areas where the terrain is rocky or at high elevation.
- It has been used with varying degrees of success around the world.

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Dart seeding

- Dart seeding is used with the same broad objective as aerial seeding: a plantation in inaccessible areas.
- The process involves throwing darts containing seeds onto open ground.
- In aerial seeding, many seeds fail to germinate.
- If dart plantation is done from a low-flying helicopter, seeds have a relatively better chance of survival as they reach deeper into the ground.
- Plantation with both aerial and dart plantations is carried out close to the onset of monsoon.

14.8. Government Initiatives to Promote Bamboo in India

- The **Indian Forest Act 1927 was amended** in 2017 **to remove bamboo from the category of trees**.
- **As a result, now anyone can undertake cultivation and business in bamboo and its products**.
- **Hence bamboo grown outside forests no longer need felling and transit permissions**.
- **Import policy has also been modified** to ensure the progress of the bamboo industry in the country.
- The restructured **National Bamboo Mission was launched in 2018-19** for the holistic development of the complete value chain of the sector.
- The **National Bamboo Mission** endeavours to upgrade the skills of traditional bamboo craftsmen as per the requirement of contemporary markets.
- 10 most important species which are required by industry have been identified and quality planting material is being made available to farmers for plantations.
- The bamboo ecosystem has been energized with 23 States being assisted, including all the 8 States of NE.
- Assam has already engaged FPOs for raising plantations.
- New FPOs will also be formed under the Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW) for the **formation of 10,000 FPOs in 5 years.**
- Primary processing centres are being set up close to the plantations which will enable cost of transportation of whole bamboo to be reduced.
- The **Sector Skill Councils** established under **National Skill Development Agency** will also impart skills and Recognition of Prior Learning to traditional artisans.

14.8.1. National Bamboo Mission

- **Restructured National Bamboo Mission** was approved in 2018.
- It is being implemented **only in the major bamboo growing states**.
- The Mission will focus on development of bamboo in **limited States** where it has social, commercial and economical advantage, particularly in the **North-eastern** region & States including Madhya Pradesh, Maharashtra, Chhattisgarh, Odisha, Karnataka, Uttarakhand, Bihar, Jharkhand, Andhra Pradesh, Telangana, etc.
- The Mission envisages promoting holistic growth of bamboo sector by adopting **area-based, regionally differentiated strategy** and to increase the area under bamboo cultivation and marketing.

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- Under the Mission, steps have been taken to increase the availability of quality planting material by supporting the setting up of new nurseries and strengthening of existing ones.
- To address forward integration, the Mission is taking steps to strengthen marketing of bamboo products, especially those of handicraft items.
- The bamboo plantations will be promoted predominantly in farmers' fields, homesteads, community lands, arable wastelands, and along irrigation canals, water bodies etc.
- According to the National Bamboo Mission, **India has the highest area (13.96 million hectares) under bamboo** and is the **second richest country after China in terms of bamboo diversity** with 136 species.
- China exports 68% of the world's bamboo and rattan products.

Major Objectives

- To increase the area under bamboo plantation in **non-forest Government and private lands**.
- To improve post-harvest management through primary processing units near the source of production.
- To promote the growth of the bamboo sector through as an area based regionally differentiated strategy.
- To increase the coverage of area under bamboo in potential areas with improved varieties.
- To promote, develop and disseminate technologies.

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15. Global Environmental Issues and Environmental Degradation

The important global environmental issues are:

- ✓ **Biodiversity Loss** (explained in the previous chapter)
- ✓ **Desertification** (explained in the chapter on Land Degradation)
- ✓ **Depletion of Ozone Layer** (explained in the chapter on Air Pollution)
- ✓ **Acid Rain** (explained in the chapter on Air Pollution)
- ✓ **Oil Spills** (explained in the chapter on Water Pollution)
- ✓ **Dumping of Hazardous Wastes** (explained in the chapter on Hazardous Waste)
- ✓ **Climate change due to global warming** (explained in the chapter on Climate Change).
- ✓ **Coral Bleaching** (explained in this chapter)
- ✓ **Persistent Organic Pollutants** (explained in this chapter)

- Environmental degradation is making the environment unfit or less suitable for the survival of different life forms, thereby causing immense **ecological damage**.
- Population explosion, urbanisation and the associated increase in human needs and comforts have resulted in rapid industrialisation.
- Rapid industrialization in turn has led to overexploitation of natural resources.
- The consequences of such exploitation are evident in the form of soil erosion, desertification, loss of biodiversity, pollution of land, air and water bodies.

15.1. Major Causes of Environmental Degradation

15.1.1. Pollution

Air Pollution

- Pollution: Gaseous pollutants: **Oxides of carbon, nitrogen,** and **sulphur**.
- Particulate matter: Fine metal dust, fly ash, soot, cotton dust and radioactive substances.
- Burning of plastics: Emits **polychlorinated biphenyls (PCBs)**.
- Industrial catastrophes: Accidental release of some poisonous gases like **phosgene ($COCl_2$)** and **methyl isocyanate** (as it happened in Bhopal in 1985).
- **Secondary air pollutants** formed from complex reactions between primary pollutants, such as **smog** and **acid rain**.
- **Global warming:** Increasing use of fossil fuels is a leading cause of increasing levels of CO_2 and other greenhouse gases in the atmosphere.

Water pollution

- Industrial and domestic effluents: Pathogens, heavy metals in water bodies and soil.
- Hazardous waste/Toxic substances: Use of a various type of chemicals today have serious health implications. The incidence of cancer, genetic mutations, and damage to nervous, immune and hormonal systems.

Soil degradation

- Deforestation, overgrazing, intensive cultivation, over irrigation etc. results in the loss of topsoil and fertility of the land. Prolonged degradation of land leads to desertification.

15.1.2. Damage to ecology and biodiversity

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- **Habitat fragmentation and destruction:** Industrialization and associated infrastructure development have led to the destruction of habitats of many species.
- **Invasive populations:** Introduction of new alien species or non-native species reduces the populations' growth of native species.
- Overexploitation and introduction of a new or **genetically modified species** **reduce the productivity of natural ecosystems**.

15.2. Consequences of Environmental Degradation

- **Increased sensitivity to diseases:** Cultivated species of plants, fishes and other domesticated animals have become increasingly sensitive to pest and diseases.
- **Genetic resistance:** An increased use of insecticides, pesticides and antibiotics has speeded up **directional natural selection** and caused **genetic resistance in pathogens**.
- **Effect on nutrient recycling:** Use of fertilisers in agricultural fields interferes with the natural biogeochemical cycles.
- **Loss of biodiversity:** Habitat destruction and habitat fragmentation are threatening the survival of many endangered species.
- **Climate change/global warming:** Air pollution is making the planet inhospitable due to events like **global warming, acid rain, ocean acidification** etc.
- **Melting of ice caps and glaciers/Sea level change:** Global warming is posing a serious threat to Himalayan and polar ecosystems by melting snow at a faster rate. Rise in sea level in future is a serious threat to coastal landforms.
- **Change in weather patterns**: The incidence of extreme weather events and change in weather patterns have become common due to environmental degradation.
- **Depletion of water resources:** Water pollution has created a tremendous scarcity of quality water resources.
- **Desertification**: Lot of arable lands is converted to wasteland due to erosion, salinity and loss of fertility.

15.3. Human Modified Ecosystems and Environmental Degradation

- Some examples of human-modified ecosystems are agro-ecosystems, plantation forests, rural and urban ecosystems, aquaculture etc.

15.3.1. Characteristics of human-modified ecosystems

- Highly unstable, unsustainable and have a devastating effect on the environment.
- Highly simplified with very low species diversity and poor nutrient cycling.
- Food chains are simple, small and undergo frequent changes.
- Depend on human (anthropogenic) support for survival.
- Species are highly susceptible to epidemic diseases.
- Highly subject to soil erosion and soil degradation.
- Regeneration and recovery of the environment are very slow.
- Some adverse effects are irreversible for a very long time.

15.3.2. Agroecosystems

- Agroecosystems are large areas where commercial crops are cultivated.
- Crops are mostly cultivated as a **monoculture** **(growing only one type of crop)** on the entire field.

Characteristics of agro-ecosystems

- Attract weeds and susceptible to plant diseases.

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- Soil are poor, deficient in nutrients, require supplement of chemical or fertilizers.
- Need artificial irrigation and water management.

Disadvantages of agro-ecosystem

- Large scale monoculture of crops results in **severe loss of native biodiversity** including **genetic diversity of crop plants**.
- High yielding varieties of crop plants are **more susceptible to disease**. E.g. smut of sugarcane, maize and sorghum and rust of wheat and bajra.
- Protecting crops from pests and diseases requires large scale use of pesticides and chemicals which pollute the environment.
- Deplete groundwater in many areas due to well irrigation.
- Runoff water from agricultural field laden with fertilisers and pesticides pollute river, lakes and ponds (**Eutrophication**).

15.3.3. Plantation Forest

- It is a humanmade ecosystem consisting of **individuals of a particular tree species**.
- The aim is to grow fast growing trees which are commercially valuable. E.g., **Palm, rubber, eucalyptus** etc.
- Plantation forest is trees planted as a **part of wasteland management** or **commercial plantations**.

Characteristics of plantation forests

- Plantation forests are generally monoculture, like oil palm plantation, rubber plantation, coffee plantation, **Jatropa curcare (biodiesel)**.
- Plantation forests have trees of the approximately the same age.
- Plantation forests are highly susceptible to pathogens.

Economic importance

- Tree plantation are raised for fruits, oil, rubber, coffee, timber, firewood, pulpwood for making rayon and paper industries.
- Trees are also planted to serve as **windbreaks or shelterbelts**.
- Tree plantations are also raised for controlling soil erosion and for increasing soil fertility.

15.3.4. Aquaculture

- Aquaculture is the artificial cultivation of aquatic plants or animals.
- It is primarily carried out for cultivating certain commercially important edible species of fresh and marine water fishes, molluscs, crustaceans and aquatic plants.
- Fisheries include the extraction of food from the sea and the fresh water whereas aquaculture is rearing of the aquatic organisms in **artificially made water bodies**, e.g. the culture of fish like carps, tilapia (also known as aquatic chicken).

There are two types of aquaculture

- Fish farming is the cultivation of fish in a controlled environment often a coastal or inland pond, lake, reservoir or rice field (paddy) and harvesting when they reach the desired size.
- **Fish ranching** is a practice of keeping fishes in captivity for the first few years in floating cages in coastal lagoons and releasing them from captivity into water bodies.
- Adults are harvested when they return for spawning to the lagoons. E.g. Salmon and Hilsa which migrate to rivers to spawn are cultivated by fish ranching method.

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Merits of aquaculture

- Ecological efficiency is high. 2 kg. of grains are required to add 1 kg live weight.
- High yield in a small volume of water.
- Improved qualities of fish obtained by selection and breeding and genetic engineering.
- Aquaculture reduces over-harvesting of fisheries.
- High profit.

Demerits of aquaculture

- Large inputs of feed, water and land are required.
- Loss of native aquatic biodiversity as it is replaced by a monoculture of a commercially important fish species.
- Produces large amounts of fish wastes that pollute water bodies.
- Aquaculture fishes are very sensitive to pesticide runoff from croplands.
- In aquaculture ponds, high population density is maintained that makes them highly vulnerable to diseases leading to total collapse of the crop.
- Aquaculture tanks or reservoirs are often get contaminated after a few years.

15.3.5. Dams, Reservoirs and Diversions

- A dam is a structure built in order to store river or tidal water.
- Dams, reservoirs and diversions capture and store runoff water and release it as needed.

They are used for:

- controlling or moderating floods,
- producing hydroelectric power, and
- supply water for irrigation, industry and other uses to rural, suburban and urban areas.
- Support recreational activities such as swimming and boating.

Advantages of dams

- Water released from dams is used to generate electricity.
- Hydroelectricity reduces dependence on coal and hence reduces CO_2 emission.
- Reduces downstream flooding.
- Reduces river silting below the dam.
- Supply irrigation water for croplands.

Disadvantages of dams

- Permanently submerge large areas of forests and croplands.
- Displace a large number of native people.
- Increase water pollution on account of reduced water flow.
- Reduce nutrients replenishment of downstream flood plains.
- Disrupt spawning and migration of some fish species.
- High costs and a long gestation period.
- Large reservoirs increase the risk of earthquakes.

Ageing Dams & Looming Crisis

- India's dams are now ageing and concomitantly (at the same time), reservoir water is being replaced by **silt**.

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- Of the over 5,200 large dams built so far, about 1,100 large dams in India have already reached 50 years of age and some are older than 120 years.
- The number of such dams will increase to 4,400 by 2050.
- This means that **80% of the nation's large dams face the prospect of becoming obsolete by 2050**.
- The situation with thousands of minor dams is even more precarious as their shelf life is even lower.
- **Krishna Raja Sagar dam** was built in 1931 and is now 90 years old.
- Similarly, **Mettur dam** was constructed in 1934 and is now 87 years old.
- Both these reservoirs are in the water-scarce Cauvery River basin.
- To make matters worse, studies show that the design of many of our reservoirs is flawed.
- The designed flood cushion within several reservoirs across many river basins may have already depleted substantially due to **siltation**.

Consequences of ageing dams

- Due to siltation **floods have become more frequent** downstream of dams.
- The flooding of Bharuch in 2020, Kerala in 2018 and Chennai in 2015 are a few examples attributed to downstream releases from reservoirs.
- The nation will eventually be unable to find sufficient water in the 21st century to feed the rising population by 2050, grow abundant crops & create sustainable cities.
- This will increase social and political tensions in the water scare regions.

Q. Which one among the following industries is the maximum consumer of water in India?

a. Engineering
b. Paper and pulp
c. Textiles
d. Thermal power

Most Water Consuming Industries:

1. Thermal power
2. Textile industry
3. Paper and Pulp
4. Iron and Steel industry
5. Fertilizer Industry

15.4. Coral Bleaching or Coral Reef Bleaching due to Environmental Degradation

15.4.1. Coral Reefs

- Coral reefs are made up of calcareous skeletons of thousands of tiny marine organisms called **coral polyps**.
- Polyps are related to **anemones and jellyfish.** They are **shallow warm water organisms** which have a soft body covered by a **calcareous skeleton**.
- The polyps extract calcium salts from seawater to form these hard tubular skeletons.
- They live in colonies on the seafloor as a cemented calcareous rocky mass, collectively called **corals**.
- When the coral polyps die, they shed their skeleton (coral) on which new polyps grow.
- The cycle is repeated for over millions of years leading to accumulation of layers of corals.
- The shallow layers of corals created by the depositions of corals is called a **coral reef**.
- Coral reefs over a period of time transform or evolve into **coral islands (e.g., Lakshadweep)**.

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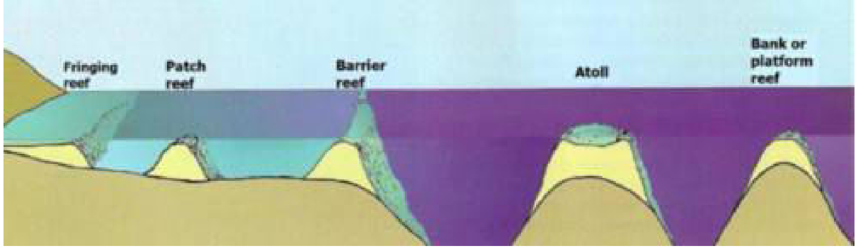
- The corals occur in different forms and colours, depending upon the **nature of salts** they are made of.
- Small marine plants **(algae)** also deposit calcium carbonate contributing to coral growth.
- **Fringing reef, barrier reef** and **atoll (coral islands are formed on atolls)** are the most important coral relief features.



- The **1200-mile long Great Barrier Reef (GBR)** off the NE coast of Australia is the world's largest reef.
- The GBR is not a single reef, but rather a very large complex consisting of **many reefs**.

15.4.2. Ideal Conditions for Coral Growth

- **Stable climatic conditions:** Corals are highly susceptible to quick changes. They grow in regions where climate is **significantly stable for a long period** (**Equatorial oceans with warm ocean currents**).
- **Perpetually warm waters:** Corals thrive in **tropical waters** (30°N and 30°S latitudes, the temperature of water is around 20°C) where **diurnal and annual temperature ranges are very narrow**.
  - ⇨ **Why are coral reefs absent on west coast of tropical continents?** **Because of Cold Ocean Currents**.
- **Shallow water:** Corals require fairly good amount of **sunlight** to survive.
- The ideal depths for coral growth are 45 m to 55 m below sea surface, where there is enough sunlight available.
- **Clear salt water:** Clear salt water is suitable for coral growth, while both freshwater and highly saline water are harmful.
- **Abundant Plankton:** Adequate supply of oxygen and microscopic marine food, called **plankton (phytoplankton)**, is essential for growth.
- As the plankton is more abundant on the **seaward side**, corals grow rapidly on the seaward side.
- **Little or no pollution:** Corals are highly fragile and are vulnerable to climate change and pollution and even a minute increase in marine pollution can be catastrophic.

15.4.3. Corals and Zooxanthellae

- Many invertebrates, vertebrates, and plants live in close association with corals, with **tight resource coupling and recycling**, allowing coral reefs to have **extremely high productivity and biodiversity**, such that they are referred to as **the Tropical Rainforests of the Oceans**.
- Scleractinian corals build skeletons of calcium carbonate **sequestered** from the water.
- Scleractinian corals come under **Phylum Cnidaria**, and they receive their nutrient and energy resources in two ways.
  1. They use the traditional cnidarian strategy of **capturing tiny planktonic organisms** with their tentacles.
  2. Having a symbiotic relationship with a **single cell alga** known as **zooxanthellae**.
- **Zooxanthellae** are **autotrophic (prepare their own food) microalgae** belonging to various taxa in the **Phylum Dinoflagellata**.

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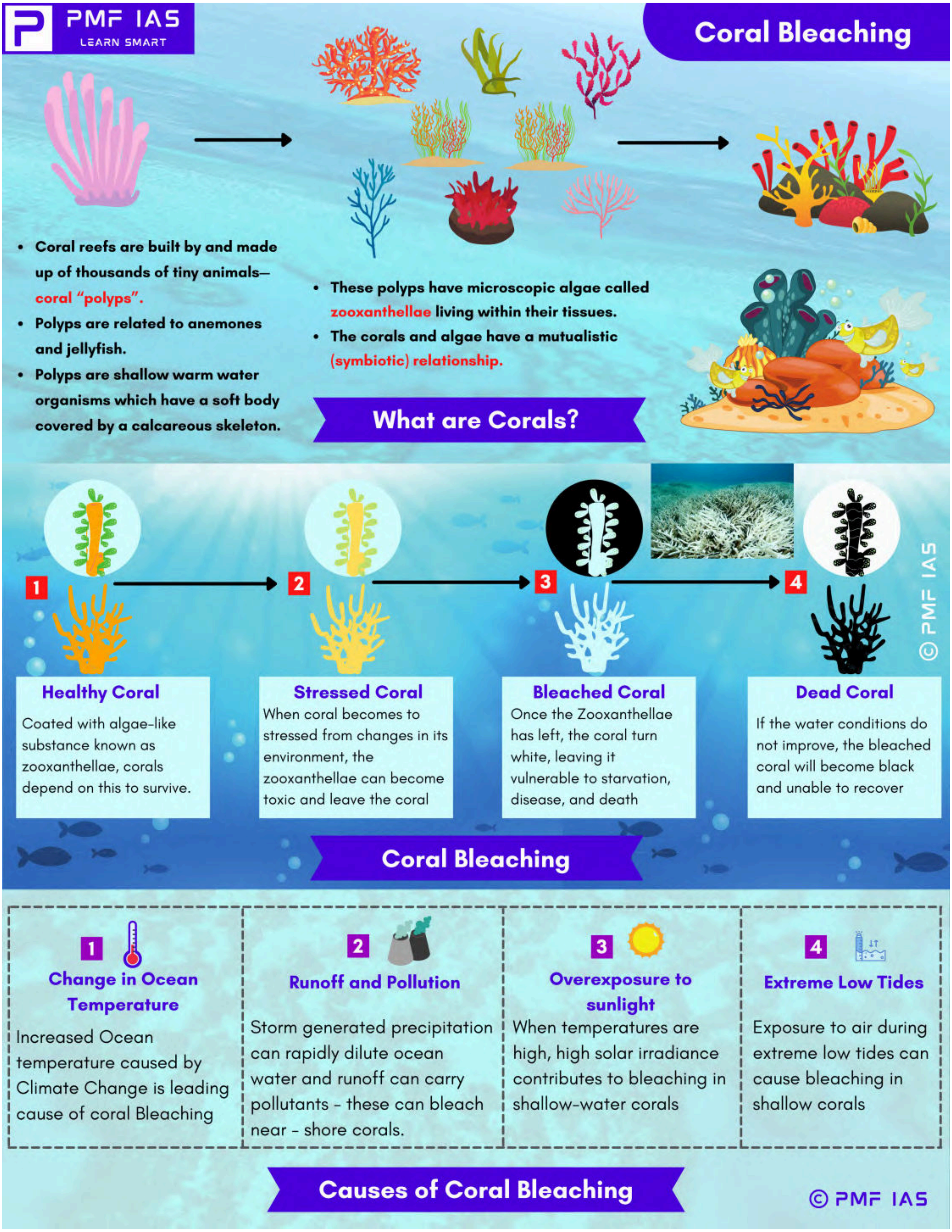

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- **Coral ➔ Phylum Cnidaria**
- **Zooxanthellae ➔ Phylum Dinoflagellata**

Symbiotic Relationship Between Corals and Zooxanthellae

- Zooxanthellae live symbiotically within the coral polyp tissues and **assist the coral in nutrient production through its photosynthetic activities**.
- These activities provide the coral with **fixed carbon compounds for energy, enhance calcification, and mediate elemental nutrient flux.**
- The host coral polyp in return provides zooxanthellae with a **protected environment** to live within, and a **steady supply of carbon dioxide** for its **photosynthetic processes**.
- The symbiotic relationship allows the **slow-growing corals** to compete with the faster growing multicellular algae.
- The corals feed by day through **photosynthesis** and by night through **predation**.
- **The tissues of corals are actually clear. The corals receive their colouration from the zooxanthellae living within their tissues**.

15.4.4. Causes for Coral Bleaching or Coral Reef Bleaching

- Disturbances affecting coral reefs include anthropogenic and natural events.
- Recent accelerated coral reef decline is related mostly to **anthropogenic impacts (overexploitation, overfishing, increased sedimentation and nutrient overloading)**. Natural disturbances which cause damage to coral reefs include **violent storms, flooding, high and low-temperature extremes, El Nino Southern Oscillation (ENSO) events, subaerial exposures, predatory outbreaks and epizootics.**
- Coral reef bleaching is a common **stress response** of corals to many of the various disturbances mentioned above.
- Bleaching occurs when,
  1. **the densities of zooxanthellae decline and/or**
  2. **the concentration of photosynthetic pigments within the zooxanthellae fall. (it is no more useful for the coral and the coral will bleach it)**
- When corals bleach, they commonly **lose 60-90% of their zooxanthellae** and each zooxanthellae may **lose 50-80% of its photosynthetic pigments**.
- If the **stress-causing** bleaching is not too severe and if it decreases in time, the affected corals usually regain their symbiotic algae within several weeks or a few months.
- If zooxanthellae loss is prolonged, i.e., if the stress continues and depleted zooxanthellae populations do not recover, the coral host eventually dies.

15.4.5. Ecological Causes of Coral Bleaching

Temperature and Ocean Acidification

- Coral species live within a relatively narrow temperature margin, and **anomalously low, and high sea temperatures** can induce coral bleaching.
- Bleaching events occur during sudden temperature drops accompanying intense upwelling episodes (El-Nino), **seasonal cold-air outbreaks**.
- While the rising temperatures have increased the frequency and intensity of bleaching, **acidification** has **reduced corals calcifying ability**.
- Small temperature increases over many weeks or large increase (3-4 °C) over a few days will result in **coral dysfunction.**
- Coral bleaching has occurred mostly during the summer seasons or near the end of a protracted warming period.

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- They are reported to have taken place during times of **low wind velocity, clear skies, calm seas and low turbidity.** The conditions favour **localised heating and high ultraviolet (UV) radiation**.
- UV radiation readily penetrates clear sea waters. The corals actually contain UV-absorbing compounds, but **rising temperatures** mean reduction in the concentration of these UV absorbing compounds in corals.

Q. Assess the impact of global warming on the coral life system with examples. (2019)

Subaerial exposure

- Sudden exposure of corals to the atmosphere during events such as **extreme low tides**, **ENSO-related sea level drops** or tectonic uplift can potentially induce bleaching.
- The consequent exposure to high or low temperatures, increased solar radiation, desiccation, and seawater dilution by heavy rains could all play a role in **zooxanthellae loss**.

Fresh Water Dilution

- Rapid dilution of reef waters from storm-generated precipitation and runoff has been demonstrated to cause coral reef bleaching.
- Generally, such bleaching events are rare and confined to relatively small, near shore areas.

Inorganic Nutrients

- Rather than causing coral reef bleaching, an increase in ambient elemental nutrient concentrations (e.g., **ammonia and nitrate**) increases zooxanthellae densities 2-3 times.
- Although **eutrophication (excessive nutrients that results in harmful algal blooms)** is not directly involved in zoo-xanthellae loss, it could cause secondary adverse effects such as **lowering of coral resistance and greater suscepti-bility to diseases.**

Xenobiotics

- When corals are exposed to high concentrations of chemical contaminants like copper, herbicides and oil, coral bleaching happens.

Epizootics

- **Pathogen** induced bleaching is different from other sorts of bleaching.
- Most coral diseases cause patchy or whole colony death and sloughing of soft tissues, resulting in a white skeleton (not to be confused with bleached corals).

Bleaching may also be Beneficial: Recent research has revealed that corals that are consistently exposed to low levels of stress may develop some kind of resistance to bleaching.

15.4.6. Australia's Great Barrier Reef

- The condition of Australia's Great Barrier Reef is in a **"critical state and deteriorating"** as **climate change warms up the waters** in which it lies, according to **IUCN**.
- In its latest report, IUCN also noted that the health of the Great Barrier Reef has worsened moving it from **"signifi-cant concern" to "critical"**.
- Citing concern, the conservation organisation highlighted that the reef suffered its third mass coral bleaching in five years during the 2019-20 summer.

Great Barrier Reef

- It is **world's most extensive coral reef ecosystem.**

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- The reef is located in the **Coral Sea, off the coast of Queensland, North-east coast of Australia.**
- It contains the **world's largest collection of coral reefs**.
- It also holds great scientific interest as the habitat of species such as the **dugong ('sea cow')** and the large **green turtle**, which are threatened with extinction.
- It was selected as a **World Heritage Site** in 1981.
- **It can be seen from outer space** and is the **world's biggest single structure made by living organisms**.

15.4.7. India's Coral Reefs

- **Climate change** induced **acidification** is causing degradation of coral reefs across the world.
- India's major coral reefs areas are in **Andaman & Nicobar Islands, Lakshadweep, Gulf of Mannar & the Gulf of Kachchh**.
- The Zoological Survey of India (ZSI) is attempting to restore coral reefs using **biorock** in the Gulf of Kachchh.
- If successful, biorock technology could potentially help to restore the degraded coral reefs.
- Biorock is the substance formed by mineral accretion or electro accumulation of minerals on steel structures that are placed on the seabed and are connected to a power source like floating solar panels.
- The technology works by passing a small amount of electrical current through electrodes in the water.
- When electric current flows between anode (+ve) and cathode (-ve) placed on the sea floor, calcium ions combine with carbonate ions and adhere to the cathode as calcium carbonate ($CaCO_3$).
- This **electroaccumulated calcium carbonate is termed as biorock**.
- Fragments of broken corals are tied to the biorock structure, where the coral larvae adhere to the $CaCO_3$ and **grow faster** as they need not spend their energy in building their own $CaCO_3$ skeletons.

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15.5. Environmental Issues in the Himalayas

- With wide-ranging natural vegetation, it acts as a **giant 'carbon sink'**.
- It is one of the most important regions of rich biodiversity, especially the eastern Himalayan region which is a global biodiversity hotspot. It is a storehouse of endemic species.

15.5.1. Degradation of Himalayan Environment

- The Himalayan region, with its young and unstable topography, is one of the most fragile ecosystems on earth.
- It has recently gained notice for its 'vulnerability' due to various unsustainable economic and developmental activities such as unchecked tourism and mountaineering, hydroelectric power projects, indiscriminate urbanisation etc.

Biotic pressure

- Population explosion has resulted in **high biotic pressure** by putting a strain on natural resources.
- Many species are now threatened due to habitat destruction and habitat fragmentation caused by anthropogenic activities.
- Man-animal conflict: snow Leopards are hunted to save livestock.

Pollution and solid waste

- Air pollution due to the increase in vehicle density; water pollution and soil pollution due to domestic sewage are making the region more vulnerable.
- Indiscriminate solid waste dumping as a result of urbanisation and tourism development have resulted in the accumulation of debris along the water courses which cause flash floods in the wet season.

Deforestation

- Deforestation in rampant all over India. In spite of their fragile ecosystem, Himalayas are no exception.
- Trees are felled for their timber which finds many domestic and industrial applications.
- Deforestation leads to soil erosion and slope instability. Landslides become common.

15.5.2. Development

Hydroelectric power projects

- Their construction has weakened the structural stability of the steep slopes causing landslides.
- Tunnel drilling has created new unnatural watercourses that cause more soil erosion and makes the stratum highly unstable increasing the risk of landslides.
- Change of river courses causes accumulation of debris in new sites which increase the chances of flash floods in the wet season.

Urbanisation to meet tourism demands

- The thriving tourist industry has created a great demand for lodging facilities. Buildings are constructed indiscriminately by flouting rules. General non-compliance with prescribed norms and guidelines has become very common.
- The natural sites for these illegal constructions are river banks, dried and old river courses and moderately sloped regions.
- During wet seasons, landslides become common along sloped regions that are affected by construction.
- The debris from the construction sites block the river courses causing flash floods. All these cause great damage to the fragile ecology.

Infrastructure development

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- Growing population, thriving tourism, military (security) needs have led to the rapid construction of roads, and railways on the Himalayan slopes.
- Instability caused by infrastructure development is evident in numerous landslides that occur in along the slopes in the region.

Cultural/Pilgrimage Tourism

- Unfortunately, most of the pilgrimage places lack adequate facilities for transport, accommodation, waste disposal and other amenities for the ever-growing number of pilgrims that visit them every year.
- Also, there is a gross lack of a regulatory mechanism for infrastructure creation, management, and for controlling the tourist inflow in such sites.
- As a result, the sensitive ecosystems and cultural values of these areas are facing pressures far beyond their carrying capacities.

15.5.3. Climate change/global warming

- Climate change has evolved as the single biggest threat to the Himalayan ecosystem.
- Melting of glaciers, ice caps and bursting of lakes create havoc downstream.
- The receding snowline has threatned local biodiversity.
- Many species acclimatised to the cold environment are moving further up the slopes. They lose their normal pray and hence struggle to survive.

15.5.4. Initiatives to save Himalayan Environment

Ban on Plastic in HP

- State government enacted the Himachal Pradesh Non-Biodegradable Garbage (Control) Act, 1995 in order to prevent throwing or depositing non-biodegradable garbage in public drains, roads.
- It was then increased the minimum thickness of plastic carry bags to 70 microns of virgin material, which exceeded the 20-micron thickness recommended by Central Rules.
- Further, the State Government has taken a Cabinet decision to ban plastics altogether in the entire state since 2009.

Participatory Conservation of Lakes in the Region

- The **Nainital Lake** is the sole source of drinking water for Nainital town, an important tourist destination in Uttarakhand state.
- An increasing inflow of tourists, urban waste making its way into the lake is adversely affecting water quality.
- To conserve the water body, the residents have switched on to a scientific garbage disposal system - under the project name 'Mission Butterfly' by Nainital Lake Conservation Project.
- The sweepers, on a small monthly charge, collect waste from each household and directly transfer it to the compost pits.
- Apart from the residents, schools and hotel owners have extended full cooperation to the authorities, to save its precious eco-system.
- In addition, they are able to generate income and employment by converting it to manure.

Assam Hill Land and Ecological Sites Act, 2006

- The Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 to prevent indiscriminate cutting of trees and filling up of water bodies in urban areas.
- Under the Act, the state government can bring any hill under its purview for protection.

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Sikkim's Ecotourism Policy

- "Sikkim - the Ultimate Tourist Destination" is the policy motto of the state.
- The state is employing a system of environmental fees and permits for entries, and stay time restrictions in some environmentally sensitive high altitude/pristine areas.
- Operationalization of tourism in various modes, such as village tourism, nature tourism, wildlife tourism, trekking/adventure tourism, and cultural tourism in the state and institutionalization of tourism management at the community level.
- Promotion and use of local art & craft, cuisines, etc., along with organizing tourism fairs and festivals.
- Imparting training in tourism-related service industries.
- The efforts made by Sikkim can be a basis of responsible tourism in other Himalayan states.

15.5.5. Measures That Can Be Taken to Protect the Himalayan Ecosystem

Harnessing Religious Sentiments for Conservation

- Encouraging devotees and tribals to undertake participatory plantation for the rehabilitation of degraded areas.
- Promoting the concept of **eco-cultural landscapes**. Both landscapes are highly evolved with a high level of economic and ecological efficiencies.
- Involving them in maintenance and strengthening of sacred groves/landscape (e.g., Sacred Groves of Meghalaya: The tribal communities - Khasis, Garos, and Jaintias, have a tradition of environmental conservation based on religious beliefs and customary law and are protected from any product extraction.)
- Himalayan Homestays: The Himalayan Homestays programme fosters conservation-based community managed tourism development in remote settlements, by gradually building local capacity and ownership.

Promoting Ecotourism and Regulation of Commercial Tourism

- Eco-tourism villages, parks, sanctuaries and other areas should be identified to establish a primary base for ecotourism.
- Village communities, especially youths, and rural women should be involved in Ecotourism.
- Restrictions on the entry of vehicles and visitors per day/ per group should be imposed on sensitive ecological sites.
- Local art, crafts, cuisines, and dishes should be promoted and made an integral part of tourist experience in order to ensure economic benefits to the locals and their cultural integrity/ entity is not lost.
- Best practices on commercial trekking should be imposed on a mandatory basis
- Creation of log/bamboo huts should be promoted in busy mountain areas.

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16. Air Pollution

- Pollution may be defined as the **addition of undesirable material** into the environment as a result of human activities. The agents which cause environmental pollution are called **pollutants**.
- A pollutant may be defined as a physical, chemical or biological substance released into the environment which is directly or indirectly harmful to humans and other living organisms.
- Pollution may be of the following types: **Air pollution, Noise pollution, Water pollution, Soil pollution, Thermal pollution and Radiation pollution**.
- In order to control environmental pollution, the Government of India has passed the **Environment (Protection) Act, 1986** (**after 1984 Bhopal disaster**) to protect and improve the quality of our air, water and soil.

16.1. Air Pollution

- Air pollution may be defined as the presence of any solid, liquid or gaseous substance **including noise** and **radioactive radiation** in the atmosphere in such concentration that may be directly and/or indirectly injurious to humans or other living organisms, property or **interferes with the normal environmental processes**.
- An ever-increasing use of fossil fuels in power plants, industries, transportation, mining, construction of buildings, stone quarries had led to air pollution.
- **Fossil fuels** contain small amounts of **nitrogen** and **sulphur**.
- Burning of fossil fuels like **coal (thermal power plants)** and **petroleum** release different **oxides of nitrogen** and **sulphur** into the atmosphere.
- These gases react with the **water vapour** present in the atmosphere to form **sulphuric acid** and **nitric acid**. The acids drop down with rain, making the rain acidic. This is called **acid rain**.
- Acid rain corrodes the marble monuments like Taj Mahal. This phenomenon is called as **Marble cancer**.
- Other kinds of pollutants are **chlorofluorocarbons (CFCs)** which are used in **refrigerators, air conditioners** and **as pressurising agents in aerosol sprays**. CFCs **damage the ozone layer** of the atmosphere.
- The combustion of fossil fuels also increases the number of **suspended particles** in the air.
- These suspended particles could be unburnt carbon particles or substances called hydrocarbons.
- Presence of high levels of all these pollutants causes visibility to be lowered, especially in cold weather when water also condenses out of the air.
- This is known as **smog** and is a visible indication of air pollution.

16.1.1. Classification of Pollutants

According to the form

- **Primary pollutants:** These are persistent in the form in which they are added to the environment, e.g. **DDT, plastic, CO, CO_2, oxides of nitrogen** and **sulphur, etc**.
- **Secondary Pollutants:** These are formed by interaction among the primary pollutants.
- For example, **peroxyacetyl nitrate (PAN)** is formed by the interaction of **nitrogen oxides** and **hydrocarbons**.
- Examples of a secondary pollutant include **ozone**, which is formed
  - ✓ when **hydrocarbons (HC) or Volatile Organic Compounds (VOCs)** and **nitrogen oxides (NO_x)** combine in the presence of **sunlight**;
  - ✓ when **NO combines** with **oxygen** in the air; and
  - ✓ due to **acid rain** (**sulphur dioxide** or **nitrogen oxides** react with rainwater to form acid rain).

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According to their existence in nature

- Quantitative Pollutants: These occur in nature and become pollutant when their concentration reaches beyond a threshold level.
- E.g., **carbon dioxide, nitrogen oxide**.
- **Qualitative Pollutants:** These do not occur in nature & are human made. E.g., fungicides, herbicides, DDT etc.

16.1.2. Noise Pollution

- Any unwanted sound that causes annoyance, irritation and pain to the human ear is termed as noise.
- Noise is measured in **dB (decibel)** which indicates the **loudness** of the sound.
- World Health Organization has prescribed optimum noise level as **45 dB by day** and **35 dB by night**.
- The human ear can tolerate noise levels up to **85 dB** and anything beyond that can affect quality of life.
- Sound above **80 dB** are considered as **loud** and **hazardous**.
- Sound between **100-125 dB** is termed as **uncomfortable**.
- The Central Pollution Control Board has laid down the permissible noise level in India for different areas.
- All the machines operating in an area should produce noise within the acceptable noise level.

Permissible noise level in India

Zone	Daytime (dB)	Night (dB)
Industrial Zone	75	70
Commercial Zone	65	55
Residential Zone	55	45
Silent Zone	50	40

- **Silent zone** includes areas that lie within **100 meters** of the premises of schools, colleges, hospitals & courts.

Laws to control Noise Pollution

- Earlier, noise pollution and its sources were addressed under the **Air (Prevention and Control of Pollution) Act, 1981**.
- They are now, regulated separately under the **Noise Pollution (Regulation and Control) Rules, 2000** under **Environment (Protection) Act, 1986**.
- Additionally, noise standards for **motor vehicles**, air-conditioners, refrigerators, **diesel generators** and certain types of construction equipment are prescribed under the **Environment (Protection) Act, 1986**.
- Noise emanating from **industry** is regulated by **State Pollution Control Boards (SPCBs)** under the **Air (Prevention and Control of Pollution) Act, 1981**.

16.1.3. Major Causes of Air Pollution

Vehicular and Industrial Emissions

- **Carbon monoxide (CO)**, **oxides of Nitrogen (NO_X)**, and **Non-Methane Volatile Organic Compounds** (**NMVOCs — benzene, ethanol, formaldehyde, cyclohexane, 1,1,1-trichloroethane or acetone**) are the major pollutants (>80%) from vehicular emissions.
- Other trace emissions include **methane (CH_4), carbon dioxide (CO_2), oxides of sulphur (SO_x)**, and **total suspended particles (TSPs)**.
- Traffic congestion exacerbates the emissions scenario.

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- Critical industries such as iron and steel, sugar, paper, cement, fertiliser, copper, and aluminium contribute to **SPM, SO_X, NO_X, and CO_2** emissions.

Improper Use of Pyrolysis

- Pyrolysis is a technique of **breaking down synthetic material** at high temperature – between 300-400 °C for an hour – in the **absence of oxygen**.
- While pyrolysis is considered a **safer technique than burning**, pyrolysis leaves **fine carbon matter, pyro gas** and **oil** as residue and the inadequate management of these by-products poses health risks.
- Many tyres pyrolysis and other industrial pyrolysis units are employing technologies that are polluting.
- The **National Green Tribunal in 2014, prohibited used tyres from being burnt in the open** or being **used as fuel in brick kilns**, because of the toxic emissions.

Applications of pyrolysis

- Used in the chemical industry to produce **methanol, activated carbon, charcoal**, etc. from wood.
- Synthetic gas produced from pyrolysis can be used in gas turbines for producing electricity.
- Mixture of soil, stone, ceramics, and glass obtained from pyrolytic waste can be used in building material.
- It can be used for cooking procedures like grilling, frying, baking, etc.
- **Pyrolysis** was recently proposed for converting billions of disposable COVID-19 PPE kits into biocrude synthetic fuel (biofuel).

Advantages of Pyrolysis

- Simple and inexpensive for processing a wide variety of feedstocks.
- Reduces waste going to landfill and greenhouse gas emissions.
- Reduces the risk of water pollution.

Fuel adulteration

- The taxes on diesel and gasoline are high compared to that on kerosene, which is meant as a cooking fuel.
- Adulteration of gasoline and diesel with lower-priced kerosene is hence rampant in India.
- Adulterated fuel increases emissions of carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter.

Emissions from Agricultural activities, Waste Treatment and Biomass Burning

- **Ammonia (NH_3), methane** and **nitrous oxide (N_2O – GHG)** are the key pollutants released from agricultural activities.
- **Methane (CH_4)** is the major pollutant released from landfills and wastewater treatment plants.
- **Ammonia (NH3)** is another by-product, which is released from the composting process.

Stubble Burning

- Stubble burning is **intentionally** setting fire to the straw stubble that remains after grains, like paddy, wheat have been harvested.
- Stubble burning makes both the **soil and air poisonous**. Microorganisms present in the upper layer of the soil as well as its organic quality gets affected.
- Stubble burning is practised in almost all parts of India. However, it has become a severe cause of concern for the National Capital Region (NCR).
- Stubble burning in **Punjab, Haryana,** and **Uttar Pradesh** to clear the fields for the sowing of **Rabi Crop** from the last week of September to November is causing severe pollution in the NCR region in winter.

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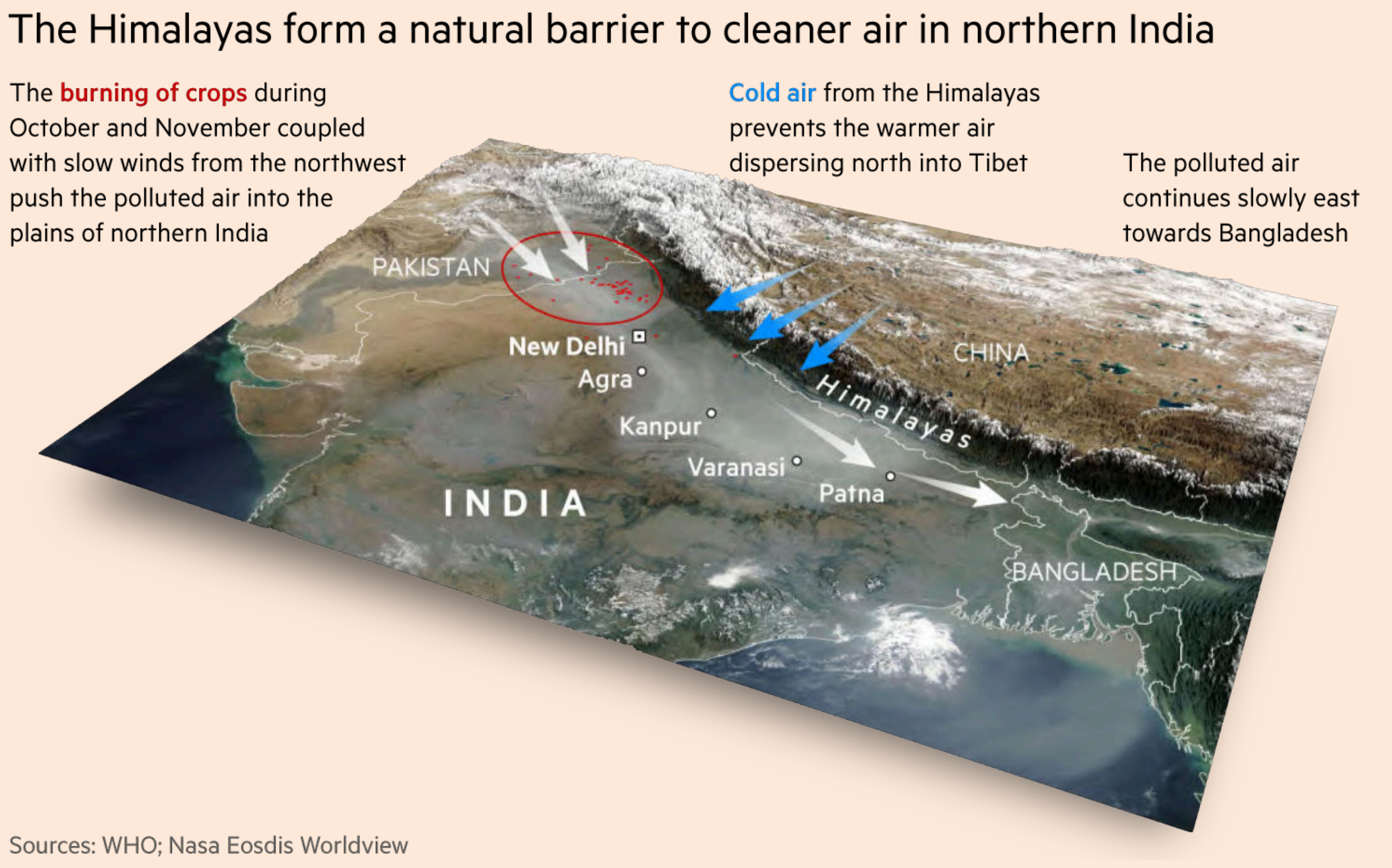
- There is only a two to three weeks' time window between the harvesting of paddy crop and the sowing of the next crop.
- Hence the pollution levels quickly rise leaving the NCR region gasping for breath.
- Burning crop residue is a crime under IPC and under the **Air and Pollution Control Act of 1981.**
- The National Green Tribunal (NGT) had banned crop residue burning in the states of Rajasthan, Uttar Pradesh, Haryana, and Punjab but the practice is still rampant.

UPSC Mains 2015 Question: Mumbai, Delhi and Kolkata are the three mega cities of the country, but the air pollution is much more serious problem in Delhi as compared to the other two. Why is this so? (200 words)

- In 2014, a global study on air quality by the WHO had declared Delhi the most polluted city in the world.
- Despite similar urbanization, air pollution is much more severe in Delhi compared to that in Mumbai and Kolkata. This is because of:

Geography and Climate

- This the most determining factor. Delhi is a **continental city** while the other two are coastal.
- **Land and See Breezes** in Mumbai and Kolkata carry pollutants away from the city. There is no such advantage to Delhi as it is land locked.
- Also, the duration of monsoon winds is short in Delhi compared to the other two.
- Delhi faces severe cold wave in winter compared to the other two. Cold climate here creates temperature inversion which traps the pollutants, mainly **smog**, for a longer duration.
- The Himalayas act as a barrier to cleaner air in North India.



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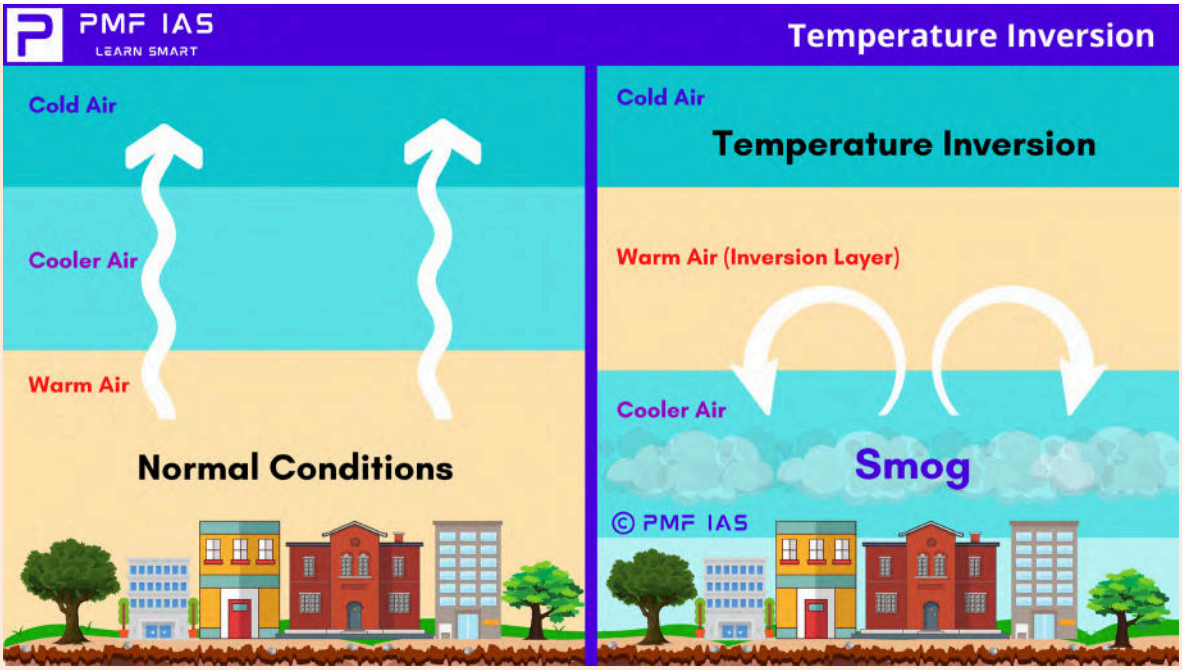

Polluting Industry in close vicinity

- Delhi & its neighbourhood (Noida, Gurugram, Ganga-Yamuna Doab) are the hot beds of polluting industries which are primarily **coal powered**.
- Burning coal releases **oxides of sulphur** which forms sulphurous smog.
- This type of smog is more pronounced in Delhi than in the other two cities due to geography and climate.

Vehicular Emissions

- All the three cities contribute nearly equal vehicular emissions rich in CO_2 and NO_2.
- NO_2 results in photochemical smog. Here again, Delhi is worst hit due to its geography and climate.

Farm Straw Burning

- Delhi is at the heart of the major agricultural region of India.
- Burning of farm straw in the surrounding regions also adds to Delhi's pollution levels.

Winters are more polluted than summers in Delhi. Why?

- The most polluted months are November, December & January, with pollution peaking in November.
- Highest volume of crop residue is burnt in Haryana, Punjab and UP in November.
- It is also when temperatures fall, and humidity rises (**temperature inversion**). Cold, foggy, windless days help in the accumulation of pollutants.
- Locally, the burning of leaves also picks up in November.

Household Air Pollution (Indoor Air Pollution)

- Household air pollution results from the burning of various fuels (coal, charcoal, wood, agricultural residue, animal dung, and kerosene, among others) for heating or for cooking with limited ventilation.
- Burning these fuels produces an array of pollutants including fine **particulate matter (PM2.5), black carbon**, **carbon dioxide**, **carbon monoxide** and **methane**.
- Paints, carpets, furniture, etc. in rooms may give out **volatile organic compounds (VOCs)**.

Volcanism – Acid Rain, Ozone Destruction

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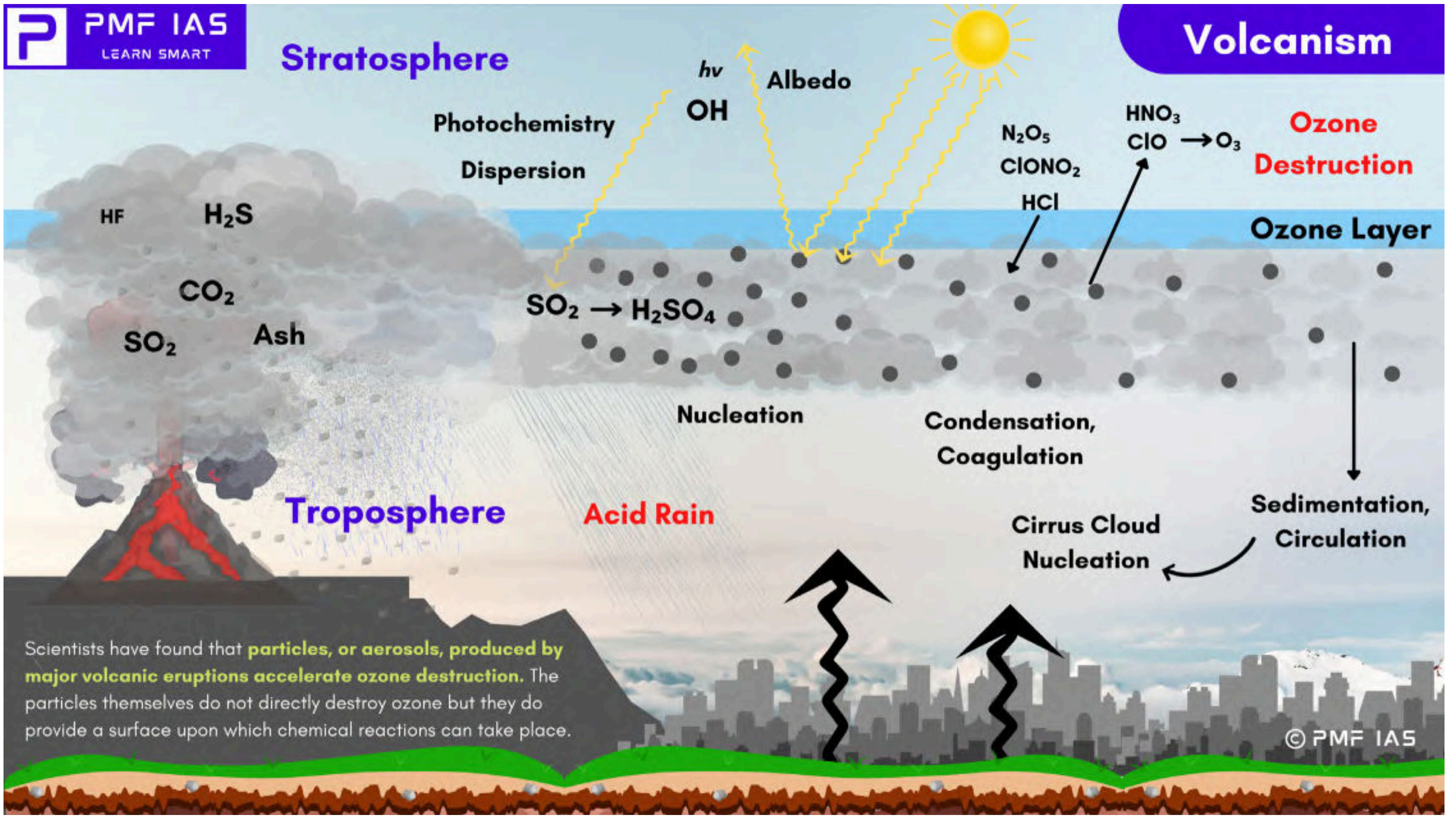
- The volcanic gases that pose the greatest potential hazard to people, animals, agriculture, and property are **sulphur dioxide, carbon dioxide**, and **hydrogen fluoride**.
- Locally**, sulphur dioxide gas can lead to acid rain** and air pollution downwind from a volcano.
- Globally, large explosive eruptions that inject a **tremendous volume of sulphur aerosols into the stratosphere** can lead to lower surface temperatures and **promote depletion of the Earth's ozone layer**.



16.2. Major Air Pollutants

16.2.1. Particulate Pollutants

- Particulate pollutants are matter suspended in air such as **dust** and **soot**.
- Their size ranges from **0.001 to 500 micrometres** (μm) in diameter.
- ✓ **Particles less than 10 μm float and move freely with the air current**.
- ✓ Particles which are more than 10 μm in diameter settle down.
- ✓ Particles less than 0.02 μm form **persistent aerosols**.
- Major source of **suspended particulate matter (SPM)** are industries, vehicles, power plants, construction activities, oil refinery, railway yard, marketplace, industries, etc.
- **Inhalable particulate matter PM10 and PM2.5** have been regarded as criteria pollutants because several studies have documented the adverse health effects of PM10 and PM2.5.
- According to the Central Pollution Control Board (CPCB), particulate size **2.5 μm or less in diameter (PM 2.5)** are responsible for causing the **greatest harm to human health**.
- These fine particulates can be inhaled deep into the lungs and can cause breathing and respiratory symptoms, irritation, inflammations, & **pneumoconiosis** (disease of the lungs caused due to inhalation of dust. It is characterised by inflammation, coughing, and fibrosis – excess deposition of fibrous tissue).

Particulate Matter Less than 2.5 μm

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- There is limited knowledge regarding size below 2.5 µm.
- In the atmosphere, **arsenic** and **nickel** exist as **particulate matter**, mostly **less than 2 µm in diameter**.
- Nickel is mainly emitted by combustion processes like petroleum processing, combustion of fossil fuels in vehicles or in power plants.
- **Nickel compounds** are classified to be **carcinogenic**.
- There has been rising concern of **PM1 (size less than 1 µm)**, while PM2.5 is 30 times finer than human hair, PM1 is 70 times finer.
- PM1 is likely to reach deeper into the respiratory system & **small enough to penetrate through the skin**.
- PM1 also contains more toxins, including metals which are able to cause lung injury and even lead to gene damage and cancer.
- The primary source of PM1 are **vehicular and industrial emissions**.
- Evidence for health effects of PM1 is limited due to **lack of monitoring**.
- There are not set standards even by WHO or any other government agencies for these ultra-fine particles.
- 40 percent of the particulate matter is as tiny as PM0.7 and is not even monitored officially.

16.2.2. Fly ash

- Fly ash is ejected mostly by **thermal power plants** as by-products of coal burning operations.
- Fly ash pollutes air and water and may cause **heavy metal pollution** in **water bodies**.
- Fly ash affects crops and vegetation as a result of its **direct deposition on leaf surfaces**.

Composition

- Fly ash particles are **oxide rich** and consist of **silica, alumina, oxides of iron, calcium, and magnesium and toxic heavy metals like lead, mercury, cadmium, arsenic, cobalt,** and **copper**.
- Major oxides present are **aluminium silicate** (in large amounts), **silicon dioxide** (SiO_2) and **calcium oxide** (CaO).

Q. Consider the following statements: (2020)

1. Coal ash contains arsenic, lead and mercury.
2. Coal-fired power plants release sulphur dioxide and oxides of nitrogen into the environment.
3. High ash content is observed in Indian coal.

Which of the statements given above is/are correct ?

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Explanation:

- **Unlike the carboniferous coal of US, Europe**, **Indian coal or Gondwana coal has high moisture and ash content**. **Hence it causes more pollution.**

Answer: d) all

Uses

- **Cement can be replaced by fly ash up to 35%**, thus reducing the cost of construction, making roads, etc.
- Fly ash **bricks** are light in weight and offer high strength and durability.
- Fly ash is a better fill material for road embankments and in concrete roads.

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- Fly ash can be used in the reclamation of wastelands.
- Abandoned mines can be filled up with fly ash.
- Fly ash **can increase crop yield** when added to the soil. But if it gets deposited on the leaf, **it will reduce photosynthesis**.
- It also enhances the **water holding capacity** of the land.

Policy measures of MoEF

- The Ministry of Environment and Forests has made it **mandatory to use Fly Ash-based products** in all construction projects, road embankment works, and low-lying landfilling works within 100 km radius of Thermal Power Station and **mine filling activities within 50 km radius** of Thermal Power Station.

Q. With reference to 'fly ash' produced by the power plants using the coal as fuel, which of the following statements is/are correct?

1) Fly ash can be used in the production of bricks for building construction
2) Fly ash can be used as a replacement for some of the Portland cement contents of concrete
3) Fly ash is made up of silicon dioxide and calcium oxide only and does not contain any toxic elements.

Select the correct answer using the code given below

a) 1 and 2
b) 2 only
c) 1 and 3
d) 3 only

Explanation:

- Fly ash does contain heavy toxic elements like arsenic, cobalt, lead etc.
- **Aluminium silicate** is the major oxide present in fly ash.

Answer: a) 1 and 2

16.2.3. Nanoparticles (NPs)

- Nanotechnology has a global socioeconomic value, with applications ranging from electronics to biomedical uses (delivering drugs to target sites).
- Human-made NPs are unknowingly or purposely released in the environment during various industrial and mechanical processes.
- Nanoparticles are particles with dimensions comparable to $1/10^9$ of a meter (1 divided by 100 crores).
- Major natural processes that release NPs in the atmosphere are **forest fires, volcanic eruptions, weathering, dust storms from desert** etc.
- Naturally occurring NPs are quite heterogeneous in size.
- They can be transported over thousands of kilometres and remain suspended in the air for several days.

Effects of Nanoparticles on the environment

- After releasing in the environment, NPs will accumulate in various environmental matrices such as air, water, soil and sediments including wastewater sludge.
- NPs in the environment influences **dust cloud formation, environmental hydroxyl radical concentration**, **ozone depletion**, or **stratospheric temperature change**.

Effect of NPs on dust cloud formation

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- NPs in environment coagulate and form dust cloud.
- Dust cloud formation **decreases sunlight** intensity.

Asian brown clouds impact on Himalayan glaciers

- Asian brown clouds carry large amounts of **soot** and **black carbon (NPs)** and deposit them on the Himalayan glaciers.
- This could lead to higher absorption of the sun's heat (**reduced albedo**) and potentially contributing to the increased melting of glaciers.

NPs and ozone depletion

- NPs can result in increased production of **reactive oxygen species (ROS), including free radicals like Cl^-**.
- **Radicals like Cl^- destroy ozone**.
  - ⇨ *In chemistry, a radical (a free radical) is an atom, molecule, or ion that has unpaired valence electrons.*

Effect of NPs on stratospheric temperature

- NPs in the troposphere interact with **molecular hydrogen** accidentally released from **hydrogen fuel cells** and other sources.
- Molecular hydrogen along with NPs **moves up to the stratosphere**, resulting in the **abundance of water vapour in the stratosphere**.
- This will cause stratospheric cooling due to the formation of **stratospheric clouds (mostly ice crystals)**.
- **Stratospheric clouds destroy ozone**.

16.2.4. Black Carbon (Soot) and Himalayan Glaciers

- Black carbon is a solid particle or **aerosol** (suspension of fine solid particles or liquid droplets in air or another gas) that contributes to **warming of the atmosphere**.
- It is a form of **particulate air pollutant**, produced from **incomplete combustion**.
- Black carbon warms the earth by **reducing albedo** (the ability to reflect sunlight) when deposited on snow.
- It is the **strongest absorber of sunlight (a lot more than carbon dioxide) and heats the air directly**.
- In addition, it darkens snowpack and glaciers through deposition and leads to **melting** of ice and snow.
- Regionally, it **disrupts cloudiness and monsoon rainfall**.
- Black carbon is said to be the **second-largest contributor to climate change after CO_2**.
- But unlike CO_2, which can stay in the atmosphere for years together, **black carbon is short-lived** and remains in the atmosphere only for days to weeks before it descends as rain or snow.
- Thus, the effects of black carbon on atmospheric warming disappear within months of reducing emissions.
- **India** and **China** are the largest emitters of black carbon in the world.
- The **Indo-Gangetic plain** will become the largest contributor of black carbon, with about 20 per cent from biofuels, 40 per cent from fossil fuels and about 40 per cent from **biomass burning**.
- The monthly mean concentration was found to be minimum in August (rainy season) and maximum in the month of May (dry season).
  - ⇨ *The presence of **pollutants in glaciers** (which are far from sources of pollution) is critical to establishing a baseline for pollution loads and estimating the contribution of various sources to pollution.*

Brown Carbon

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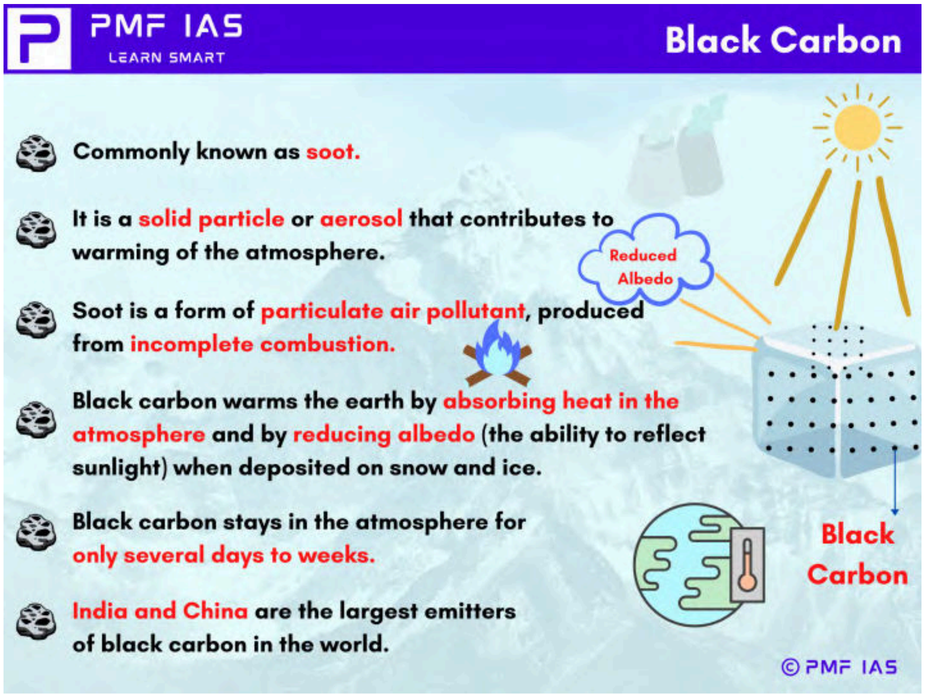
- Brown carbon is generally referred for greenhouse gases and black carbon particles resulting from impure combustion, such as soot and dust.
- Biomass burning is shown to be a major source of brown carbon.



Q. There is some concern regarding the nanoparticles of some chemical elements that are used by the industry in the manufacture of various products. Why?

1) They can accumulate in the environment and contaminate water and soil.
2) They can enter the food chains.
3) They can trigger the production of free radicals.

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: d) all

16.2.5. Carbon monoxide (CO)

- Carbon monoxide (CO) is a colourless, odourless, tasteless, and highly toxic gas that is **slightly less dense than air**. It is **short-lived** (lasts only for a few months) in the atmosphere.
- Carbon monoxide forms when there is **not enough oxygen to produce carbon dioxide (CO_2)**.
- In the presence of oxygen, carbon monoxide burns with a **blue flame**, producing carbon dioxide.
- Worldwide, the largest source of carbon monoxide is **natural in origin**, due to **photochemical reactions in the troposphere**.
- Other natural sources of CO include **volcanoes, forest fires**, and other forms of combustion.
- Anthropogenic carbon monoxide is produced from the exhaust of **internal combustion engines** and **incomplete combustion** of various other fuels.
- **Iron smelting** also produces carbon monoxide as a by-product.

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Health Effects

- **Carbon monoxide poisoning** is the most common type of fatal air poisoning (poor ventilation and heat management in laptops and other electrons can lead to the release of CO).
- It is toxic to **haemoglobin animals (including humans)** when encountered in concentrations above about **35 ppm**.
- It combines with **haemoglobin** to produce **carboxyhaemoglobin**, which **usurps the space in haemoglobin that normally carries oxygen**.

Environmental Effects

- Carbon monoxide (CO) is **not considered a direct greenhouse gas (GHG)**.
- In the atmosphere, it is spatially variable and **short-lived**, having a role in the **formation of ground-level ozone (tropospheric ozone)** and **can elevate concentrations of methane (a strong GHG)**.

16.2.6. Carbon dioxide (CO_2)

- Colourless and odourless gas.
- It is **heavier than air**.
- Natural sources include **volcanoes, hot springs** and **geysers**, and it is freed from **carbonate rocks by dissolution in water and acids**.
- Because carbon dioxide is **soluble in water**, it occurs naturally in groundwater, rivers and lakes, in ice caps and glaciers and also in seawater.

Effects on Health

- CO_2 is an **asphyxiant gas** (asphyxia: a condition arising when the body is deprived of oxygen, causing unconsciousness or death.).
- Concentrations of 7% may cause suffocation, even in the presence of sufficient oxygen, manifesting as dizziness, headache, and unconsciousness.

Effects on Environment

- Carbon dioxide is an important **greenhouse gas**.
- Burning of carbon-based fuels since the industrial revolution has led to **global warming**.
- It is also a major cause of **ocean acidification** because it dissolves in water to form **carbonic acid**.

16.2.7. Ozone (O_3)

- Ozone (O_3) forms less than 0.00005% by volume of the atmosphere and is unevenly distributed.
- Ozone is formed naturally in the **stratosphere (good ozone – formed due to the interaction between O_2 and UV light)** and absorbs harmful **ultraviolet rays** of the sun.
- However, at the **ground level (bad ozone)**, it is a pollutant (**greenhouse gas**) with highly toxic effects.
- Ground level (tropospheric) ozone is **not emitted directly into the air**.
- Some of it is **transported** from the **stratosphere**.
- The rest is formed when the pollutants like **carbon monoxide, nitrogen dioxide** and **volatile organic compounds (VOC – oil & gas extraction) react in the presence of sunlight at the ground level** and **convert O_2 to O_3**.
- Ozone is most likely to reach unhealthy levels on **hot sunny days**.
- It can also be transported long distances by wind, so even rural areas can experience high O_3 levels.

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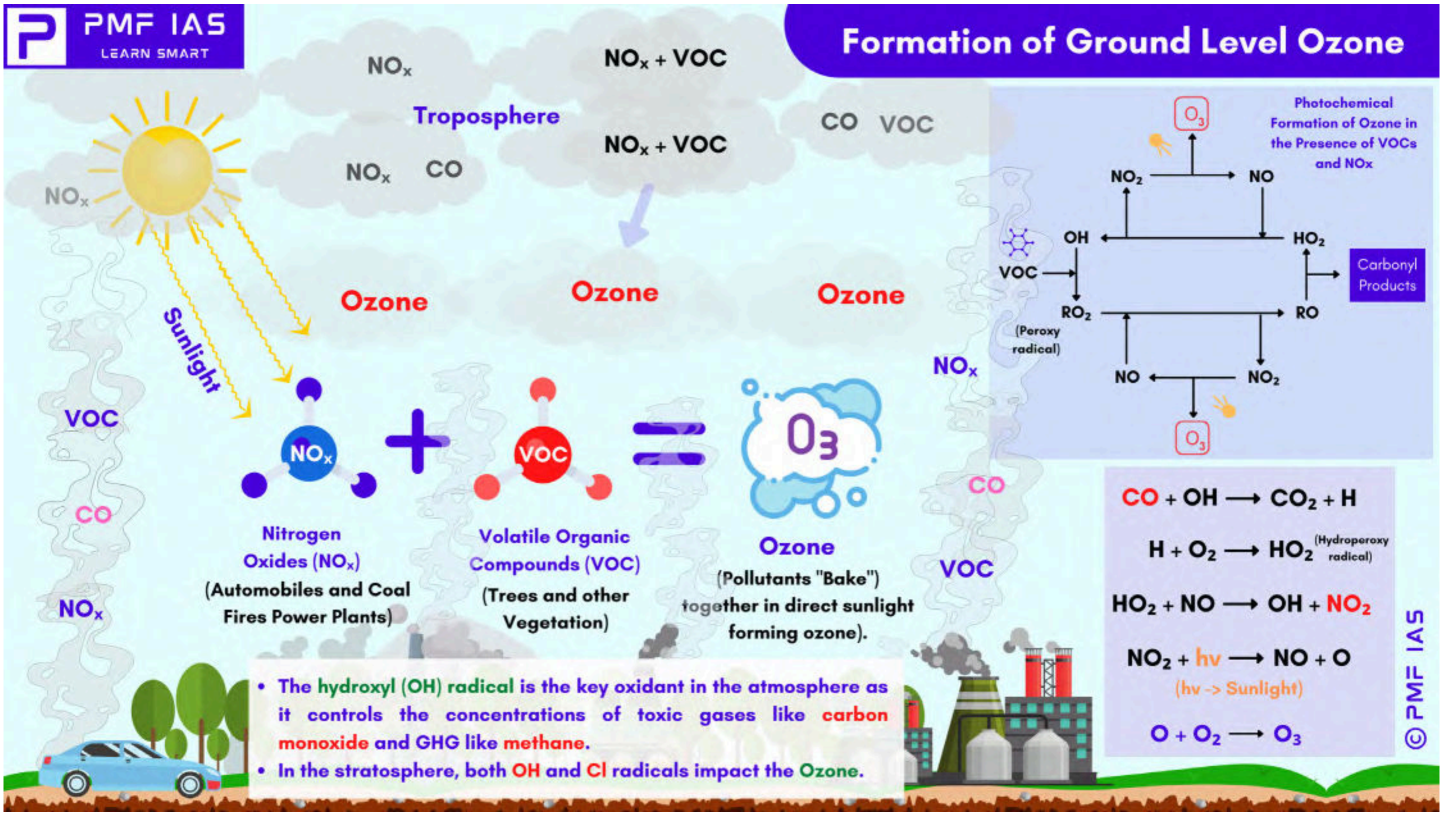

Reactions Involved in the Formation of Ground Level Ozone

1. **Carbon monoxide** reacts with **hydroxyl radical (-OH)** to produce **hydroperoxy radical (HO_2)**.
2. **Volatile Organic Compounds** reacts with **hydroxyl radical (-OH)** to produce **peroxy radical (RO_2)**.
3. **Hydroperoxy radical / Peroxy radical** reacts with **nitrogen oxide (NO)** to form **nitrogen dioxide (NO_2)** & **hydroxyl radical (OH) / alkoxy radical (RO)**.
4. **NO_2 gives O_3 via photolysis** (separation of molecules by the action of light).

Harmful Effects of Ozone

- Ozone at ground level is a **harmful air pollutant**, because of its effects on people and the environment, and it is one of the main ingredient in "smog."
- Ozone makes our eyes itchy, and watery. It lowers our resistance to cold and pneumonia.
- Asthma patients are at greatest risk of harm from breathing air containing ozone.
- Elevated exposures to ozone can affect sensitive vegetation and ecosystems, including forests, especially during the growing season.

16.2.8. Stratospheric Ozone Depleting Substances

- Ozone depleting substances are human-made gases that destroy **stratospheric ozone (good ozone)**.
- They include:
  1. **chlorofluorocarbons (CFCs)**
  2. **hydrochlorofluorocarbons (HCFCs)**
  3. **hydrobromoflurocarbons (HBFCs)**
  4. **halons** (halocarbon gases were used in **fire extinguishers**)
  5. **methyl bromide** (was used as **fumigant** for pest control — suffocating pests with poison)
  6. **carbon tetrachloride** (formerly widely used in **fire extinguishers**, **refrigerant** & as a **cleaning agent**)

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7. methyl chloroform (**solvent for organic compounds**; used for **cleaning metals & circuit boards**).

Ozone depleting substances have been used as:

- refrigerants in commercial, home and vehicle air conditioners and refrigerators
- foam blowing agents
- a component in electrical equipment
- industrial solvents
- solvents for cleaning (including dry cleaning)
- aerosol spray propellants
- fumigants

Chlorofluorocarbons (CFCs)

- **Chlorofluorocarbons** are used in **aerosol sprays** and as **refrigerants** in **refrigerators** & **air conditioners**.
- They are also considered **greenhouse gases** that cause climate change.
- Since the late 1970s, the use of CFCs has been heavily regulated because of their **destructive effects on the ozone layer**.
- There are still CFCs left in older industrial air conditioning and refrigeration systems.
- The **Montreal Protocol** on **Substances that Deplete the Ozone Layer** (a protocol to the **Vienna Convention for the Protection of the Ozone Layer**) is an **international treaty** designed to **protect the ozone layer** by **phasing out the production of numerous ozone depleting substances** including **CFCs**.

Hydrochlorofluorocarbons

- Hydrochlorofluorocarbons (HCFCs) have been used as a **substitute for CFCs**.
- HCFCs do **less damage to the ozone layer than CFCs**.

Halons

- Halons are **halocarbon gases** that were originally developed for use in **fire extinguishers**.
- In halons one or more carbon atoms are linked by covalent bonds with one or more **halogen atoms (fluorine, chlorine, bromine or iodine)**.
- Production and consumption of halons ended in 1994 in developed countries.

Q. Consider the following statements: Chlorofluorocarbons, known as ozone-depleting substances, are used

1. in the production of plastic foams
2. in the production of tubeless tyres
3. in cleaning certain electronic components
4. as pressurizing agents in aerosol cans

Which of the statements given above is/are correct?

a. 1, 2 and 3 only
b. 4 only
c. 1, 3 and 4 only
d. 1, 2, 3 and 4

Explanation:

- CFCs were used as refrigerants, pressurizing agents (foam and aerosol cans) and for cleaning electronic equipment.

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Answer: c)

16.2.9. Nitrogen oxides (Oxides of Nitrogen) (NO_x)

- NO_x is a generic term for the various nitrogen oxides produced during **combustion**.
- They are produced mainly in **internal combustion engines** and **coal-burning power plants**.
- They are also produced naturally by **lightning**.
  - ⇨ *Oxygen and nitrogen do not react at ambient temperatures. But at **high temperatures**, they produce various oxides of nitrogen. Such temperatures arise inside an **internal combustion engine** or a **power station boiler**.*
- **Agricultural fertilisation** and the **use of nitrogen-fixing plants** also contribute to atmospheric NO_x, by promoting nitrogen fixation by microorganisms.
- **Nitrogen Oxide (NO) and Nitrogen Dioxide (NO_2) contribute to global cooling** and should not be confused with **nitrous oxide (N_2O)**, which is a **greenhouse gas** and has many uses as an **oxidiser**.

Effects on Health and Environment

- They are believed to aggravate **asthmatic conditions** and create many respiratory health issues.
- The reduction of NO_x emissions is one of the most important technical challenges facing **biodiesel**.
- NO_x gases react to form **smog** and **acid rain** as well as being central to the formation of **tropospheric ozone**.
- When **NOx and volatile organic compounds (VOCs)** react in the **presence of sunlight**, they form **photochemical smog**.
- Mono-nitrogen oxides eventually form **nitric acid** when dissolved in atmospheric moisture, forming a component of **acid rain**.
- **NO and NO_2 emissions** cause **global cooling** through the formation of **-OH radicals** that **destroy methane molecules (methane cycle)**, **countering the effect of greenhouse gases**.

16.2.10. Sulphur dioxide (SO_2)

- Sulphur dioxide is a toxic gas with a pungent, irritating smell. It contributes to **acid rain**.
- It is released naturally by **volcanic activity**. It is abundantly available in the **atmosphere of Venus**.
- It is also produced by:
  - ✓ **burning coal in thermal power plants** and **diesel fuels**.
  - ✓ some industrial processes, such as the **production of paper** and **smelting of metals like copper**.
  - ✓ reactions involving **Hydrogen Sulphide (H2S) and oxygen**.
  - ✓ The **roasting of sulphide ores** such as **pyrite, sphalerite, and** **cinnabar (mercury sulphide)**.
- Sulphur dioxide is primarily produced for sulfuric acid manufacture.
- It is a poisonous air pollutant that increases the risk of stroke, heart disease, lung cancer & other health issues that can lead to premature death. It also weakens the functioning of certain nerves.

India's SO_2 Emissions

- **Greenpeace India** & the **Centre for Research on Energy & Clean Air (CREA)** has released its annual report titled "**Ranking the World's Sulphur Dioxide (SO_2) Hotspots: 2019-2020**".
- **India** has continued to occupy the **top spot in the world** in **sulphur dioxide (SO_2) emissions** for the **fifth consecutive year** in 2019.
- **China's success** in reducing SO_2 emissions has made **Russia** the second highest emitter after India.
- In 2019, India emitted **21%** of global anthropogenic (human made) SO_2 emissions.

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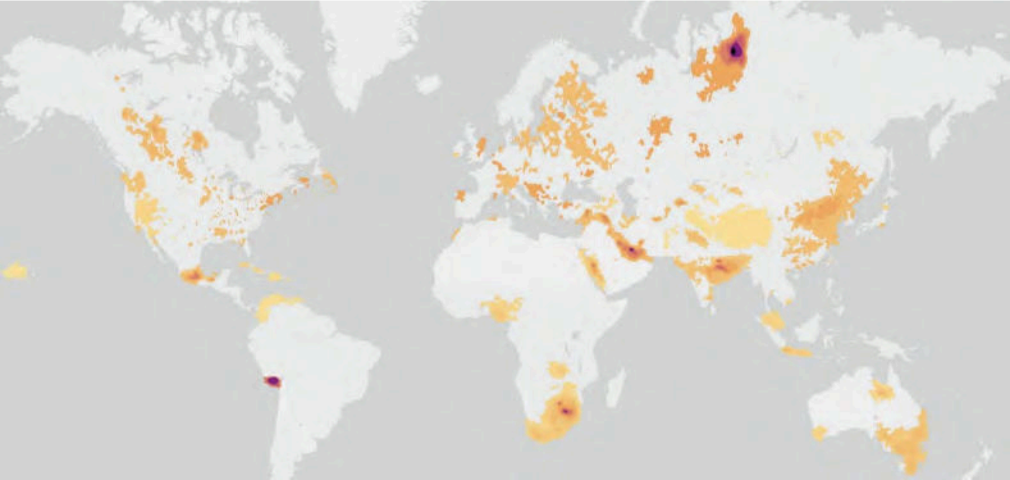
- **Electricity generation using coal** remains the largest contributor of SO_2 emissions.
- However, India's SO_2 emissions have recorded a decline of approximately six percent in 2019 as compared to 2018, the steepest dip in four years.



World's Sulphur Dioxide (SO_2) Hotspots: 2019-2020

SO_2 Emission Hotspots in India

- India has more than 15 per cent of all anthropogenic sulphur dioxide (SO_2) hotspots in the world detected by the **OMI (Ozone Monitoring Instrument) satellite**.
- The biggest emission hotspots in India are **thermal power stations** (or clusters of power stations).
- The major SO_2 emission hotspots in India are
  - ✓ **Singrauli in MP,**
  - ✓ **Neyveli & Chennai in Tamil Nadu,**
  - ✓ **Talcher & Jharsuguda in Odisha,**
  - ✓ **Korba in Chhattisgarh,**
  - ✓ **Kutch in Gujarat,**
  - ✓ **Ramagundam in Telangana &**
  - ✓ **Chandrapur & Koradi in Maharashtra**.
- Among large cities, **Chennai** is one of the biggest emission hotspots in the country.

16.2.11. Volatile organic compounds (VOCs)

- Volatile Organic Compounds (VOCs) are a large group of **carbon-based** chemicals that **easily evaporate** at room temperature.
- For example, **formaldehyde**, which evaporates **from paint**, has a boiling point of only –19 °C.
- Formaldehyde causes irritation to the eyes and nose and allergies.
- The main indoor sources are **perfumes, hair sprays, furniture polish, glues, air fresheners, moth repellents, wood preservatives**, and other products.
- Health effects: irritation of the eye, nose and throat, headaches, nausea and loss of coordination.
- Long term health effects: suspected to damage the liver and other parts of the body.

16.2.12. Benzene

- Benzene is a **natural constituent** of **crude oil** and is one of the elementary petrochemicals.
- Because benzene has a **high octane number** and is an important component of **gasoline (petrol)**.

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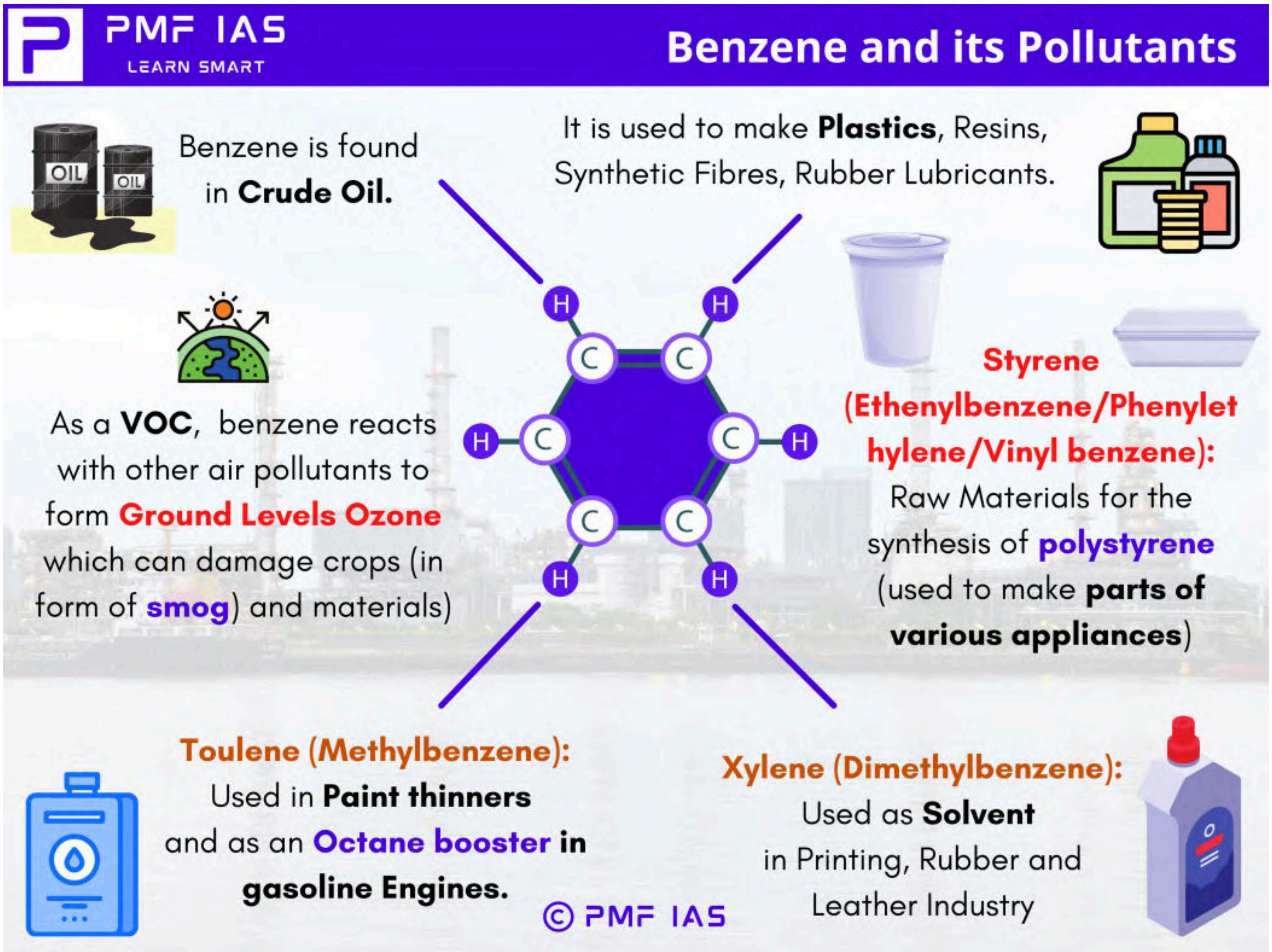
- Benzene is used to make **plastics, resins, synthetic fibers, rubber lubricants**, etc.
- As a **Volatile Organic Compound**, benzene reacts with other air pollutants to form **ground levels ozone** which can damage crops (in the form of **smog**) and materials).
- Benzene increases the **risk of cancer** and **bone marrow failure**.

Benzene Pollutants

- **Toluene (methylbenzene):** used in **paint thinners** and as an **octane booster in gasoline engines**.
- **Xylene (dimethylbenzene): used as a solvent** in printing, rubber, and leather industry.
- **Styrene (ethenylbenzene / phenylethylene / vinylbenzene):** raw material for synthesis of **polystyrene** (used to make **parts of various appliances**).



Styrene Gas

- Styrene gas leak from LG Polymers chemical factory in Visakhapatnam in May 2020 left several dead.
- Styrene is an organic compound that is a **derivative** of **benzene**.
- It is in **stored in liquid state** and **evaporates easily (Volatile Organic Compound)**.

What is styrene used for?

- It is the main **raw material for synthesis of polystyrene**.
- Polystyrene is a versatile **plastic** that is used to make **parts of various appliances** such as refrigerators or micro-ovens, automotive parts, computers, disposable items, etc.

What happens if someone is exposed to styrene gas?

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Molecular structure of styrene (C_8H_8), with bonding in the form $C_6H_5CH=CH_2$. Used for synthesis of plastics, it is stored as a liquid in factories but evaporates rapidly.

Short term Effects

- It affects the **central nervous system.**
- It causes breathlessness, irritation in eyes, indigestion & nausea, & loss of consciousness.
- It is the **mucous membrane** that is mainly affected by exposure to styrene gas, and it **can be fatal**.

Long-term effects

- There is a chance developing **leukaemia** and headaches in patients.

Q. Which of the following are the reasons/factors for exposure to benzene pollution?

1. Automobile exhaust
2. Tobacco smoke
3. Wood burning
4. Using varnished wooden furniture
5. Using products made of polyurethane

Select the correct answer using the code given below:

a) 1, 2 and 3 only
b) 2 and 4 only
c) 1, 3 and 4 only
d) 1, 2, 3, 4 and 5

Explanation:

- Automobile exhaust, wood burning, and varnished furniture are obvious answers.
- **Nicotine, aerosol particles, carbonyls, volatile organic compounds** and hundreds of other chemicals are used in cigarettes.
- **Polyurethane** is a polymer used in insulation of refrigerators, cushioning for furniture, sportswear, etc.

Answer: d) all

16.3. Minor Air Pollutants

16.3.1. Lead

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- It is present in **petrol, diesel, lead batteries, paints, hair dye** products, etc.
- **Tetraethyl lead (TEL)** is used as an **anti-knock agent in petrol** for a smooth and easy running of vehicles.
- The lead particles coming out from the exhaust pipes of vehicles when inhaled produce injurious effects on **kidney and liver** and interferes with the **development of red blood cells**.
- Lead can cause **nervous system damage** and digestive problems and, in some cases, cause cancer.
- It has long term effects on children as it lowers intelligence.
- Lead mixed with water and food can create cumulative poisoning.

16.3.2. Ammonia (NH_3)

- Ammonia (NH_3) is a corrosive, colourless gas with a distinctive, pungent odour.
- It is commonly emitted in nature by **decaying organic matter** and **human and animal waste**.
- Most of the anthropogenic NH_3 emissions come from **livestock management** & **agricultural fertilizers**.
- NH_3 is poisonous and is irritating to the eyes, nose, and throat in lesser amounts.
- It combines in the atmosphere with **sulphates** and **nitrates** to form **ammonium salts** which are **secondary fine particulate matter (PM2.5)**.
- NH_3 is highly soluble in water and can contribute to the **nitrification** & **eutrophication** of aquatic systems.

Q. Consider the following statements: (2019)

1. Agricultural soils release nitrogen oxides into environment.
2. Cattle release ammonia into environment.
3. Poultry industry release reactive nitrogen compounds into environment.

Which of the statements given above is/are correct?

a) 1 and 3 only
b) 2 and 3 only
c) 2 only
d) 1, 2 and 3

Explanation:

- **Agricultural fertilisation** and the **use of nitrogen-fixing plants** contribute to atmospheric NO_x, by promoting nitrogen fixation by microorganisms.

Answer: d) all

16.3.3. Ethylene

- Ethylene is widely used in the chemical industry.
- Much of this production goes toward **polyethylene**, a widely used plastic containing polymer chains of ethylene units in various chain lengths.
- **Ethylene** is also an important **natural plant hormone**, used in agriculture **to force the ripening of fruits**.
- Ethylene is of low toxicity to humans and exposure to excess ethylene cause adverse health effects like headache, drowsiness, dizziness, and unconsciousness.
- Ethylene is not but **ethylene oxide is a carcinogen (cancer-causing agent)**.

16.3.4. Asbestos

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- Asbestos refers to a set of six naturally occurring **silicate fibrous minerals** — chrysotile, crocidolite, amosite, anthophyllite, tremolite, and actinolite.
- It is now known that prolonged inhalation of asbestos fibres can cause serious and fatal illnesses including **lung cancer, mesothelioma,** and **asbestosis** (a type of pneumoconiosis). Others

Metallic Oxides

- Oxides of iron, aluminium, manganese, magnesium, zinc and other metals have an adverse effect due to deposition of dust on plants during mining operations and metallurgical processes.
- They create physiological, biochemical, and developmental disorders in plants and also contribute towards reproductive failure in plants.

Biological pollutants

- It includes **pollen** from plants, mite, and hair from pets, spores of fungi, parasites, and some bacteria.
- Most of them are allergens and can cause asthma, hay fever, and other allergic diseases.

Radon

- It is a gas that is emitted naturally by the **soil**.
- Due to modern houses having poor ventilation, it is confined inside the house and causes lung cancers.

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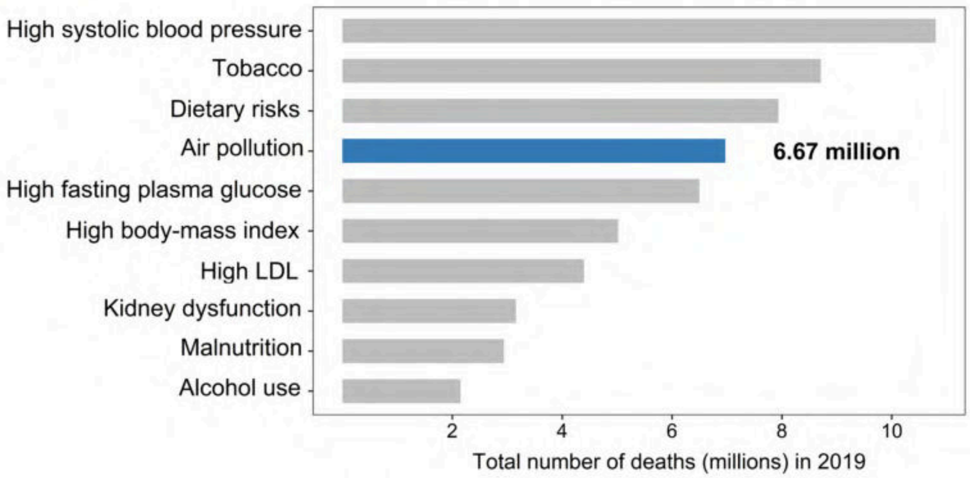
17. Effects of Air Pollution

17.1. Air Pollution is the 4th Greatest Killer – State of Global Air 2020

- '**State of Global Air 2020**', released by the **Health Effects Institute** (an **independent** global health and air pollution research institute) showed that the exposure to outdoor and indoor air pollution contributed to over **1.67 million annual deaths** (**more than 55%** due to exposure to **outdoor pollution**) in India in 2019.
- Globally, **6.67 million deaths** in 2019 were attributable to air pollution. **4.14 million** of these deaths were due to **outdoor PM2.5 exposure** and the rest **2.31 million** deaths were due to **household air pollution**.
- **India** had the **highest** population-weighed annual average **exposure** to **PM2.5**.
- **India** also had the **3rd highest** population-weighed annual average **exposure** to **Ozone**.
- **Air pollution** was the **fourth major cause of all deaths in 2019.**

FIGURE 1 Global ranking of risk factors by total number of deaths from all causes in 2019.



17.1.1. Occupational Health Hazards

Black lung disease

- In coal mining areas coal dust is the main air pollutant.
- The deposits of coal dust make miners lungs look black instead of a healthy pink and hence the name black lung disease. Black lung disease is the common name for **pneumoconiosis (CWP) or anthracosis**, a lung disease of older workers in the coal industry, caused by inhalation over many years, of small amounts of coal dust.
- The particles of fine coal dust accumulate in the lungs. Eventually, this build-up causes thickening and scarring making the lungs less efficient in supplying oxygen to the blood.

Chemicals and Biological Agents

- Substances such as **benzene, chromium, nitrosamines** and **asbestos** may cause cancers of lung, bladder, skin, mesothelium, liver, etc.
- Occupational asthma is caused due to exposure to organic dust, microorganisms, bacteria, fungi and moulds and several chemicals.
- **Silicosis** first reported from Kolar gold mines in 1947 is a common disease among miners, pottery and ceramic industry workers.
- **Pneumoconiosis** and **byssinosis** are common among mica and textile industry workers respectively.

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17.2. Smog (smoke + fog)

- Smog is caused by the burning of **coal, vehicular emission** and **industrial fumes** (primary pollutants).
- Smog contains soot particulates like smoke, **ozone (O_3), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2)** & others. At least two distinct types of smog are recognised: **sulphurous smog** & **photochemical smog**.

17.2.1. Sulphurous smog

- Sulphurous smog is also called **London smog** (first formed in London due to **industrial revolution**).
- Sulphurous smog results from a high concentration of **sulphur oxides** in the air and is caused by the use of **sulphur-bearing fossil fuels, particularly coal** (main source of electricity generation in India).
- This type of smog is aggravated by **dampness** and a **high concentration of suspended particulate matter** in the air.

17.2.2. Photochemical smog

- Photochemical smog is also known as **summer smog or Los Angeles smog**.
- Photochemical smog occurs most prominently in urban areas that have large numbers of **automobiles** (**nitrogen oxides** are the primary emissions).
- Photochemical smog forms when **nitrogen oxides** (primary pollutant) & **volatile organic compounds** react together in the presence of sunlight to form **ozone (secondary pollutant)**.
- The resulting smog causes a light brownish colouration of the atmosphere, reduced visibility, plant damage, irritation of the eyes, and respiratory distress.

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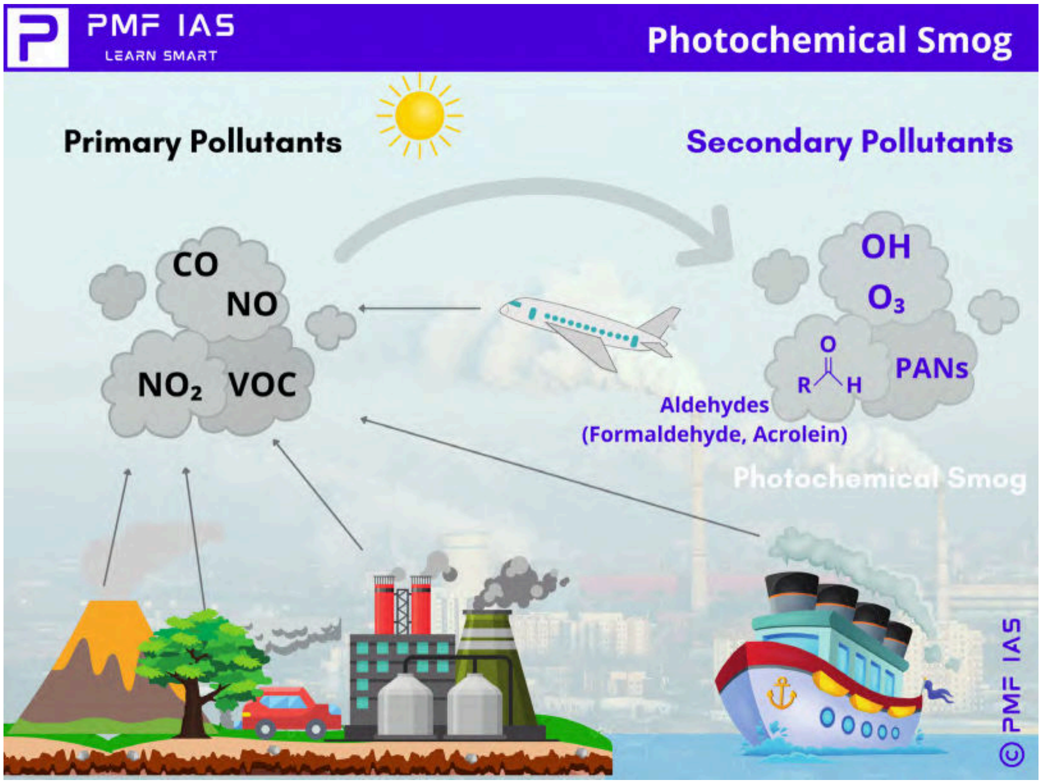

17.2.3. Haze

- Haze is traditionally an atmospheric phenomenon where dust, smoke and other dry particles obscure the clarity of the sky (**no condensation involved**. Smog is like haze but **there is condensation in smog**).
- Sources for haze particles include farming (ploughing in dry weather), traffic, industry, and wildfires.

NO + VOC (volatile organic compounds) ——→ NO_2 (Nitrogen Dioxide)

NO_2 + UV (sunlight) ——→ NO + O (Nitrogen Oxide + atomic oxygen)

O + O_2 ——→ O_3 (Ozone)

NO_2 + VOC ——→ PAN (peroxyacetyl nitrate – $C_2H_3NO_5$), etc.

Result: NO + VOC + O_2 + UV ——→ O_3, PAN, and other oxidants like OH

17.2.4. Effects of Smog

Toxic Chemical	Sources	Environmental Effects
Nitrogen Oxides (NO and NO_2)	• combustion of oil, coal, gas • bacterial action in soil • forest fires, volcanic action • lightning	• decreased visibility due to yellowish colour of NO_2 • NO_2 can suppress plant growth
Volatile Organic Compounds (VOCs)	• evaporation of fuels • incomplete combustion of fossil fuels	• eye irritation • respiratory irritation • some are carcinogenic • decreased visibility due to blue-brown haze
Ozone (O_3)	• formed from photolysis of NO_2 • sometimes results from **stratospheric ozone intrusions**	• decreased crop yields • retards plant growth • **damages plastics** • breaks down rubber

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Peroxyacetyl Nitrates (PAN)	• formed by the reaction of NO_2 with VOCs	• eye irritation • high toxicity to plants • **damaging to proteins**

- The **atmospheric pollution** levels of Los Angeles, Beijing, Delhi, Mexico City and other cities are increased by **inversion** that traps **smog** close to the ground. It is usually highly toxic to humans and can cause severe sickness, shortened life or death.
- Temperature inversions are accentuated, and **precipitation is reduced** due to smog. Smog-related Haze lowers visibility.

17.3. Acid Rain – Acidification

- Acid rain refers to any precipitation (rain, fog, mist, snow) that is more acidic than normal (**pH of less than 5.6**. pH below 7 is acidic).
- Acid rain is caused by atmospheric pollution from acidic gases such as **sulphur dioxide (SO_2)** and **oxides of nitrogen (NO_X)** emitted from the **burning of fossil fuels**.
- It is also recognized that acidic smog, fog, mist, move out of the atmosphere and settle on dust particles which in turn accumulate on vegetation as acid depositions.
- When rain falls, the acid from these depositions leak and form acid dews.

17.3.1. The pH scale

- The pH scale is a measure of how acidic or basic (alkaline) a solution is.
- It ranges from 0 to 14. A **pH of 7 is neutral**. A **pH less than 7 is acidic**, and a **pH greater than 7 is basic**.
- It is based on **hydrogen ion concentration** in an aqueous solution.
- **pH values decrease** as **hydrogen ion levels increase**.
- A solution with pH 4 is ten times more acidic than pH 5, and a hundred times more acidic than pH 6.
- Whilst the pH range is usually given as 0 to 14, lower and higher values are theoretically possible.

17.3.2. Gases that cause acid rain

Acidic gases	Source
SO_x (Sulphur oxides)	• Fossil fuel burning, power plants, smelting of metal sulphide ores, industrial sources, industrial production of sulfuric acid in metallurgical, chemical and fertiliser industries, **volcanoes**, **seas and oceans**, **decomposition of organic matter**, etc.
NO_x (Nitrogen oxides – NO, NO_2 and N_2O)	• Fossil fuel burning, lightning, **biomass burning, forest fires, oceans**, power plants.

(NO and N_2O are mentioned in NIOS Environment)

Q. Acid rain is caused by the pollution of the environment by

a) carbon dioxide and nitrogen
b) carbon monoxide and carbon dioxide
c) ozone and carbon dioxide
d) nitrous oxide and sulphur dioxide

Explanation:

- **CO** and **CO_2** react with rainwater to form **weak carbonic acid**. Hence, rainwater is **naturally slightly acidic**. But this is

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not enough to call it acid rain (acid rain must have **pH of less than 5.6**).

- **Even increased concentration of CO and CO_2 is not enough to cause rainwater of pH less than 5.6**.
- Only NIOS (10.3.2 Gaseous pollutants > Table 10.3 – Page 167) mentions **N_2O (nitrous oxide)**.

More details:

- **N_2O and NO are neutral in nature**.
- N_2O_3, NO_2 and N_2O_5 are acidic in nature.
- These **acidic oxides react with water** and produce acids like **HNO_3 (nitric acid)** and **HNO_2 (nitrous acid)** which causes acid rain.
- The neutral oxides are comparatively less, and they combine with oxygen and produce **nitrogen dioxide**.
- Thus, **N_2O** and **NO** are **indirectly involved** ($2NO + O_2 \rightarrow 2NO_2$) in causing acid rain.

Answer: d) nitrous oxide (laughing gas; a strong GHG) and sulphur dioxide

17.3.3. Types of Acid Deposition

- "Acid rain" is a broad term referring to a mixture of wet and dry deposition (a form of deposition material) from the atmosphere.

Wet Deposition

- If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to the ground in the form of **rain, snow, fog, or mist**.
- As this acidic water flows over and through the ground, it affects a variety of plants and animals.

Dry Deposition

- In areas where the weather is dry, the acid chemicals may become incorporated into **dust or smoke** and fall to the ground through dry deposition, **sticking to the ground, buildings, vegetation, cars**, etc.
- Dry deposited gases and particles can be washed from these surfaces by rainstorms, through runoff. This runoff water makes the resulting mixture more acidic.
- About half of the acidity in the atmosphere falls back to earth through **dry deposition**.

17.3.4. Chemistry of Acid Rain

Six basic steps are involved in the formation of acid rain:

1. The atmosphere receives **oxides of sulphur and nitrogen** from natural and human-made sources.
2. Some of these oxides fall back directly to the ground as **dry deposition**, either close to the place of origin or some distance away.
3. **Sunlight** stimulates the formation of **photo-oxidants** (**such as ozone**) in the atmosphere.
4. These photo-oxidants interact with the oxides of sulphur & nitrogen and other gases (like NH_3) to produce **H_2SO_4 (sulphuric acid)** and **HNO_3 (nitric acid)** by oxidation.
5. Acid rain containing ions of **sulphate, nitrate, ammonium** and **hydrogen** falls as **wet deposition**.

17.3.5. Harmful Effects of Acid Rain

- Acid rain affects both aquatic & terrestrial organisms.
- It also damages buildings and monuments.

Effects on soil

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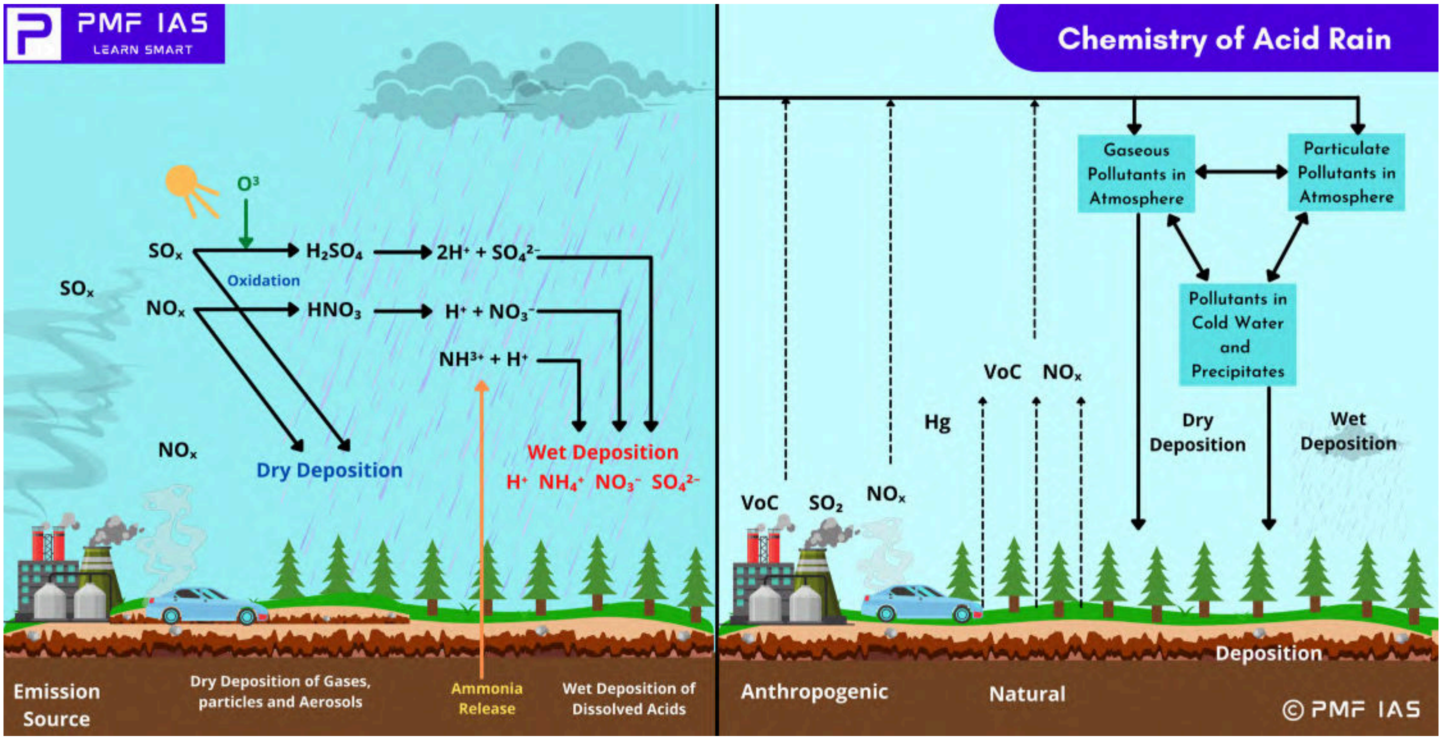
- The exchange between **hydrogen ions** and the nutrient cations **like potassium** & **magnesium** in the soil cause **leaching** of the nutrients, making the soil infertile.
- An increase in **ammonia** in the soil due to a decrease in other nutrients **decreases the rate of decomposition**. The nitrate level of the soil is also found to decrease.
- The impact of acid rain on soil is less in India; because Indian soils are mostly **alkaline, with good buffering ability**.

Effects on humans

- Bad smell, reduced visibility, irritation of the skin, eyes and the respiratory tract.
- Some direct effects include chronic bronchitis, pulmonary emphysema and cancer.

Effects on aquatic life

- **Eggs** or sperms of fish, frogs and other aquatic organisms are sensitive to pH changes.
- Acid rain kills their gametes affecting the life cycles and productivity (ecosystem imbalances).
- Acidic lake waters may kill microbes and turn them unproductive.
- Acid rain can make metals bound on soils to be released into the aquatic environment.



Effect on terrestrial life

- Acid rain damage **cuticle** of plant leaves and reduces photosynthesis.
- Acidic medium promotes **leaching** of heavy metals like **aluminium, lead** and **mercury**. Such metals when percolate into ground water affect soil micro flora/fauna.
- Other indirect effects of acid rain on wildlife are loss or alteration of food and habitat resources.

Effects on microorganisms

- pH determines the proliferation of any microbial species.
- The optimum pH of **most bacteria and protozoa** is near **neutrality.**
- **Most fungi** prefer an **acidic environment**.
- **Blue-green bacteria** prefer an **alkaline environment**.
- So, **microbial species** in the soil and water shift from **bacteria-bound to fungi-bound.**

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- This causes a **delay in the decomposition of soil organic material (happens in taiga vegetation)**.

Effect on buildings, monuments and materials

- Limestone and marble are destroyed by acid rain. Smoke and soot cover such objects. They slowly dissolve/flake away from the surfaces because of acid fumes in the air.
- Many buildings/monuments such as Taj Mahal in Agra have suffered from acid rain (**Marble Cancer**).

17.3.6. Acid Rain Areas

- They are concentrated in the industrialised belt of the northern hemisphere — Scandinavia, Canada, Japan, the North-east United States and North-western Europe.

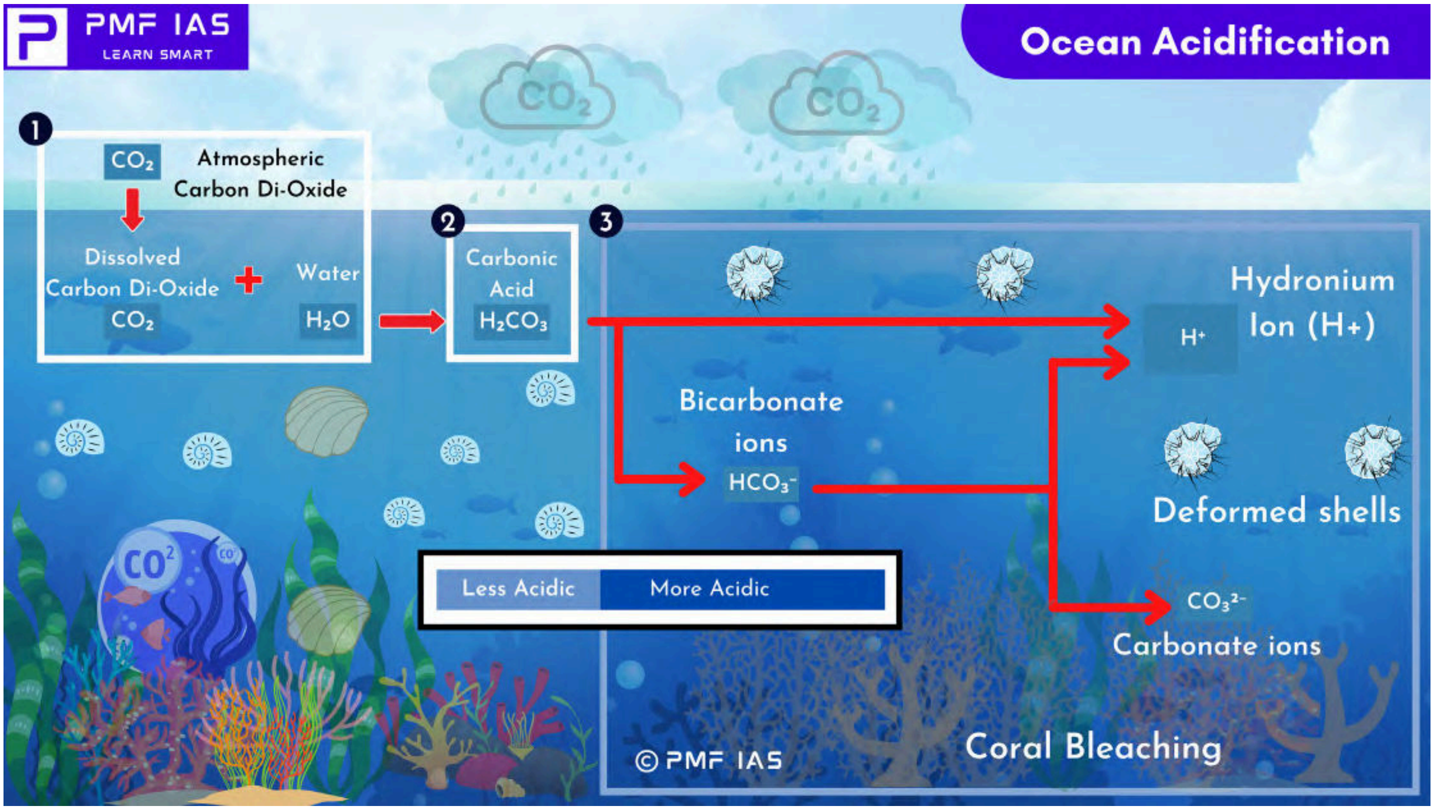
In India

- In India, the first report of acid rain came from Bombay in 1974.
- Instances of acid rain are being reported from many metropolitan cities.
- Lowering of soil pH is reported from north-eastern India, coastal Karnataka and Kerala, parts of Orissa, West Bengal and Bihar.

17.3.7. Acid Rain Control

- Use of **low sulphur fuel** or natural gas or **washed coal** (chemical washing of pulverised coal) in **thermal plants** can reduce incidences of acid rain.
- **Buffering:** practice of adding a neutralising agent to the acidified water to increase the pH. Usually, lime in the form of **calcium oxide** & **calcium carbonate** is used.

17.4. Ocean Acidification



- Ocean acidification has been called the "**evil twin of global warming**" and "**the other CO_2 problem**".

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- Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of **carbon dioxide (CO_2)** from the atmosphere.
- An estimated **30–40%** of the carbon dioxide from human activity released into the atmosphere dissolves into oceans, rivers, and lakes.
- To achieve chemical equilibrium, some of it reacts with the water to form **carbonic acid**.
- Some of these **extra carbonic acid molecules** react with a **water molecule** to give a **bicarbonate ion** and a **hydronium ion (H+)**, thus **increasing ocean acidity (H+ ion concentration)**.
- Checking **CO** and **CO_2 emissions** and controlling pollution are the only means to reduce ocean acidification.

17.4.1. Other contributors

- **Eutrophication** leads to large **plankton blooms**, and when these blooms collapse and sink to the seabed the subsequent **respiration of bacteria decomposing the algae** leads to a **decrease in seawater oxygen** and an **increase in CO_2 (a decline in pH)**.

17.4.2. Effects of Ocean Acidification

Reduced Buffering Capacity

- **Oceans** are an important **reservoir for CO_2**, absorbing a significant quantity of it (one-third) produced by anthropogenic activities and effectively **buffering climate change**.
- The uptake of atmospheric carbon dioxide is occurring at a rate **exceeding the natural buffering capacity** of the oceans.
- Increasing acidity **depresses metabolic rates** and **immune responses** in some organisms.

Adversely Affects Marine Calcifying Organisms

- Seawater absorbs CO_2 to produce carbonic acid, bicarbonate and carbonate ions.
- However, the increase in atmospheric CO_2 levels lead to a decrease in pH level, an increase in the concentration of carbonic acid and bicarbonate ions, causing a **decrease in the concentration of carbonate ions**.
- The decrease in the amount of carbonate ions available makes it more **difficult for marine calcifying organisms, such as coral (calcareous corals)** and **some plankton (calcareous plankton)**, to form biogenic calcium carbonate.
- Commercial fisheries are threatened because acidification harms **calcifying organisms** which form the **base of the Arctic food webs**.
- Increasing acidity **accentuates coral bleaching** as corals are overly sensitive to changes in water composition.

Impact of Ocean Acidification on Cloud Formation

- Most of the **sulphur** in the atmosphere is **emitted from the ocean**, often in the form of **dimethylsulfide (DMS) produced by phytoplankton**.
- Some of DMS produced by phytoplankton enters the atmosphere and reacts to make **sulphuric acid**, which clumps into aerosols, or microscopic airborne particles.
- **Aerosols seed the formation of clouds**, which help **cool the Earth** by reflecting sunlight.
- But, in acidified ocean water, **phytoplankton produces less DMS**.
- This reduction of sulphur may lead to **decreased cloud formation, raising global temperatures**.

Q. The acidification of oceans is increasing. Why is this phenomenon a cause of concern?

1) The growth and survival of calcareous phytoplankton will be adversely affected.
2) The growth and survival of coral reefs will be adversely affected.

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3) The survival of some animals that have phytoplanktonic larvae will be adversely affected.
4) The cloud seeding and formation of clouds will be adversely affected.

Which of statements given above is / are correct?

a) 1, 2 and 3 only
b) 2 only
c) 1 and 3 only
d) 1, 2, 3 and 4

Explanation:

- We have already learnt that ocean acidification decreases the calcifying ability of corals, calcareous plankton, crustaceans etc. It also adversely affects cloud formation and cloud seeding. So, options 1, 2 and 4 are correct.

Answer: d) 1, 2, 3 and 4

Artificial Cloud seeding

- Cloud seeding is the process of **spreading either dry ice** or more commonly, **silver iodide aerosols**, into the upper part of clouds to try to **stimulate the precipitation process (condensation)** and form rain.
- Since most rainfall starts through the growth of **ice crystals** from super-cooled cloud droplets in the upper parts of clouds, the **silver iodide** particles are meant to **encourage the growth of new ice particles**.

17.5. Aerosols from Air Pollution and their Impact on Monsoon Rainfall

- Scientists have found that **aerosols** have led to **increased incidents of high rainfall events in the foothills of the Himalayan Region (causing regional disparity in rainfall distribution)**.
- The region is associated with **high aerosol loading**, much of which is black carbon & **dust**.
- Here, the **air mass** is forced from a low elevation to a higher elevation (rainfall due to orographic forcing).

17.5.1. Aerosols

- An **aerosol** is a **suspension of fine solid particles or liquid droplets in air or another gas**.
- Aerosols can be natural or anthropogenic.
  1. Examples of **natural aerosols** are **fog, mist, dust, forest exudates** & **geyser steam.**
  2. Examples of **anthropogenic aerosols** are **particulate air pollutants** & **smoke.**
- In the atmosphere, these particles are mainly situated in the **low layers of the atmosphere (< 1.5 km)** since aerosol **sources** are located on the **terrestrial surface**.
- However, certain aerosols can still be found in the stratosphere, especially **volcanic aerosols** ejected into the high-altitude layers.
- Effects of aerosols:
  1. They affect the atmospheric chemical composition.
  2. They can reduce the visibility.
  3. They have important impacts on air quality & human health.
  4. They serve as **nuclei for cloud droplets or ice crystals** in ice clouds.

17.5.2. Impact of Aerosols on Monsoon

- Aerosol remains one of the most uncertain factors in climate projection.

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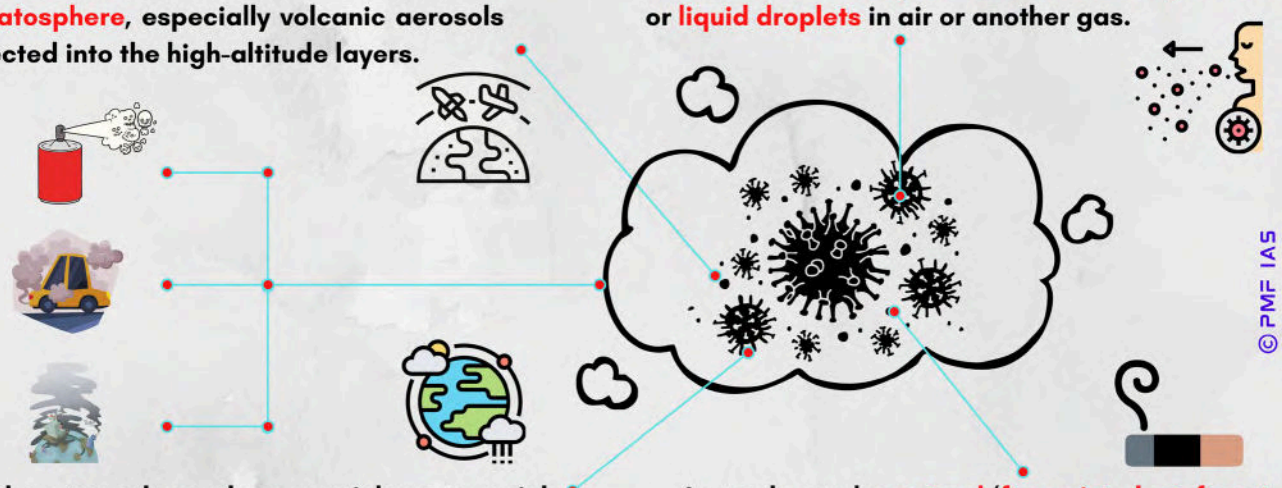
Aerosols from Air Pollution and their Impact on Monsoon Rainfall

Why in News? Scientists have found that aerosols have led to increased incidents of high rainfall events in the foothills of the Himalayan Region (causing regional disparity in rainfall distribution).

What are Aerosols?

An aerosol is a **suspension of fine solid particles** or **liquid droplets** in air or another gas.

Certain aerosols can still be found in the **stratosphere**, especially volcanic aerosols ejected into the high-altitude layers.

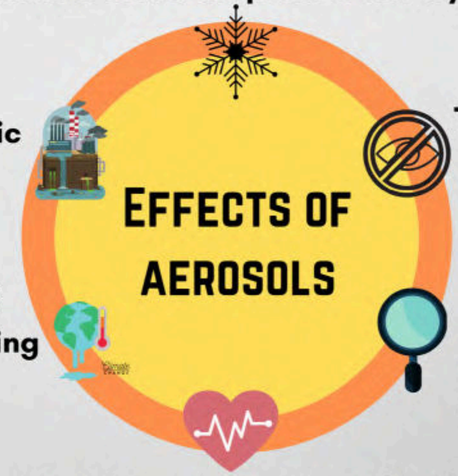


In the atmosphere, these particles are mainly situated in the **low layers of the atmosphere** (< 1.5 km).

Aerosols can be **natural** (**fog, mist, dust, forest exudates & geyser steam**) or **anthropogenic** (**particulate air pollutants & smoke**).

Effects of Aerosols

They serve as nuclei for cloud droplets or ice crystals in ice clouds.



They affect the atmospheric chemical composition.

They can reduce the visibility.

Affects radiative balance of Climate Change (by Scattering or Absorbing)

Modify Optical properties & Lifetime of Clouds

They have important impacts on air quality & human health.

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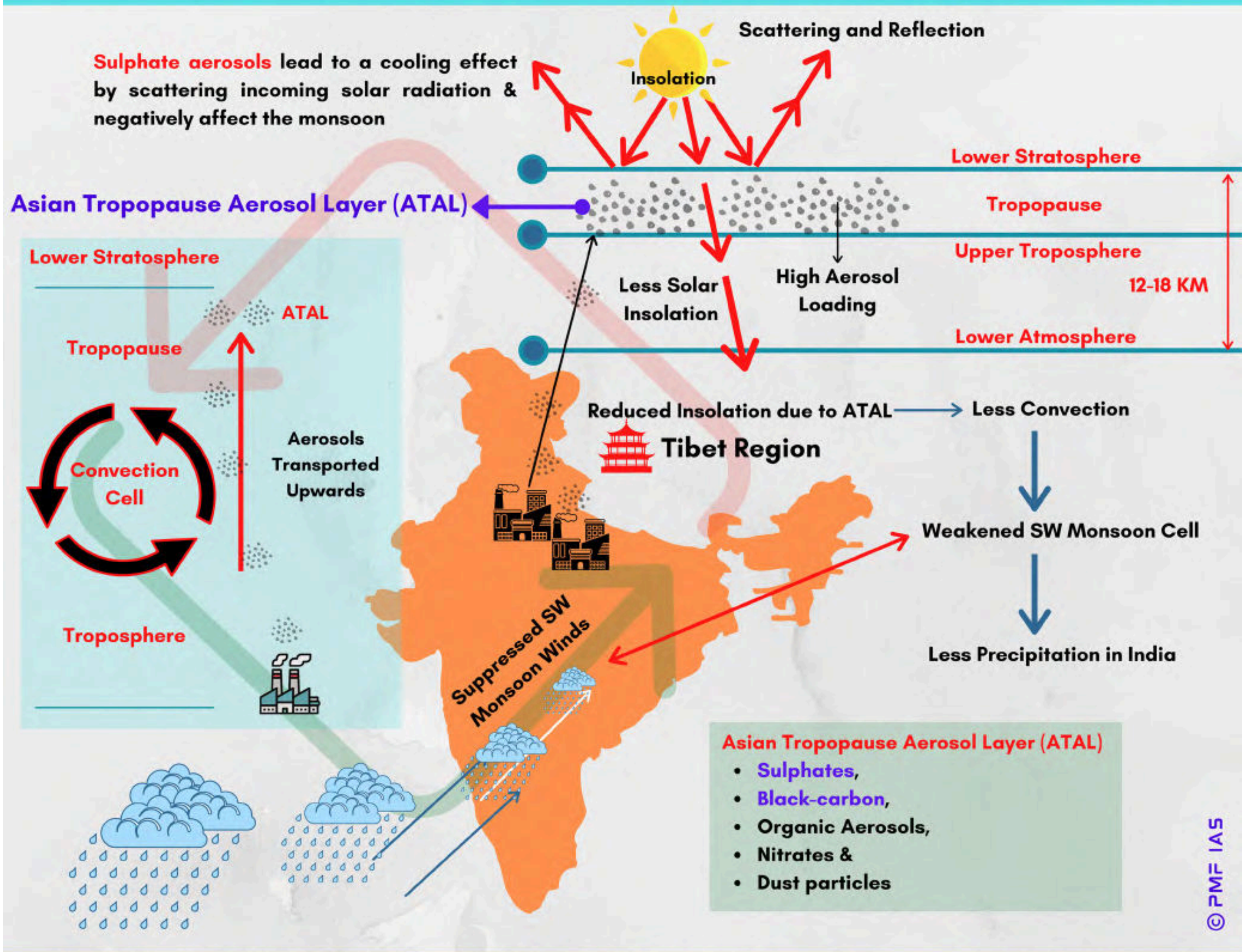
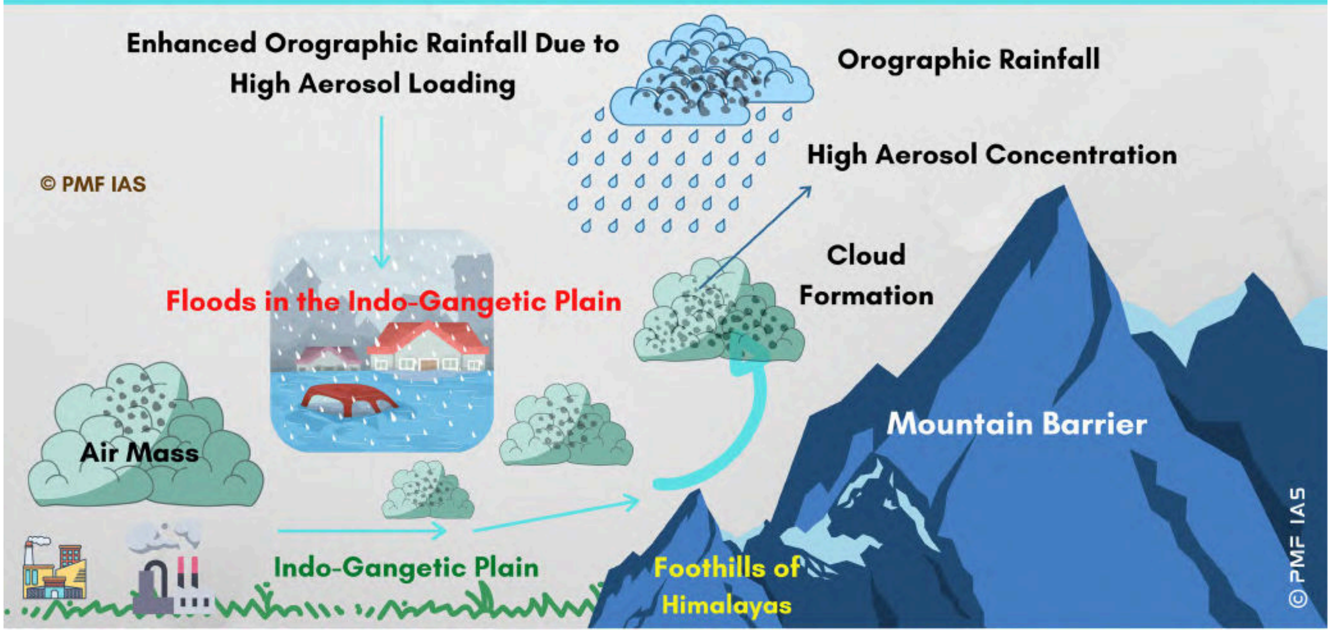
Impact of Aerosols on a Macroscale (Indian Monsoon)



Impact of Aerosols on Monsoons in the Himalayan Foothills



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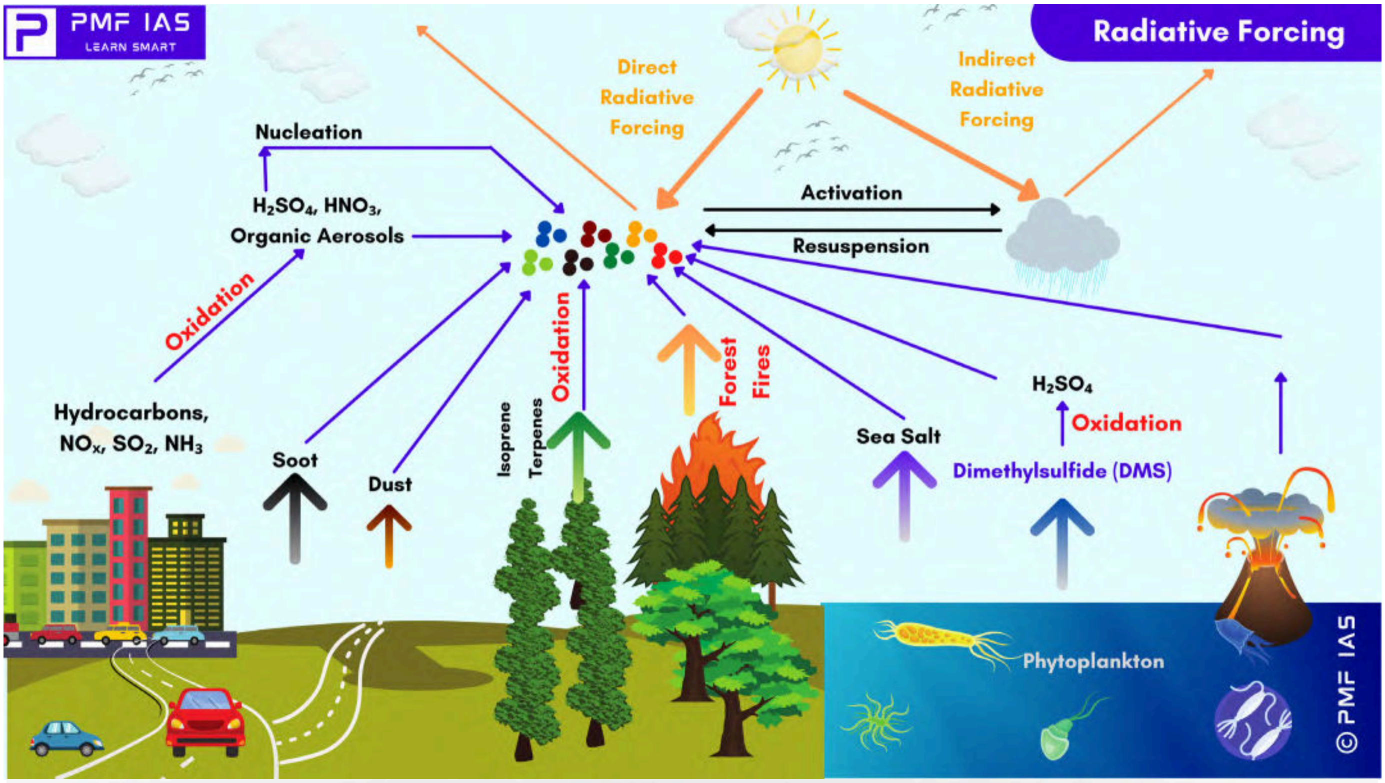

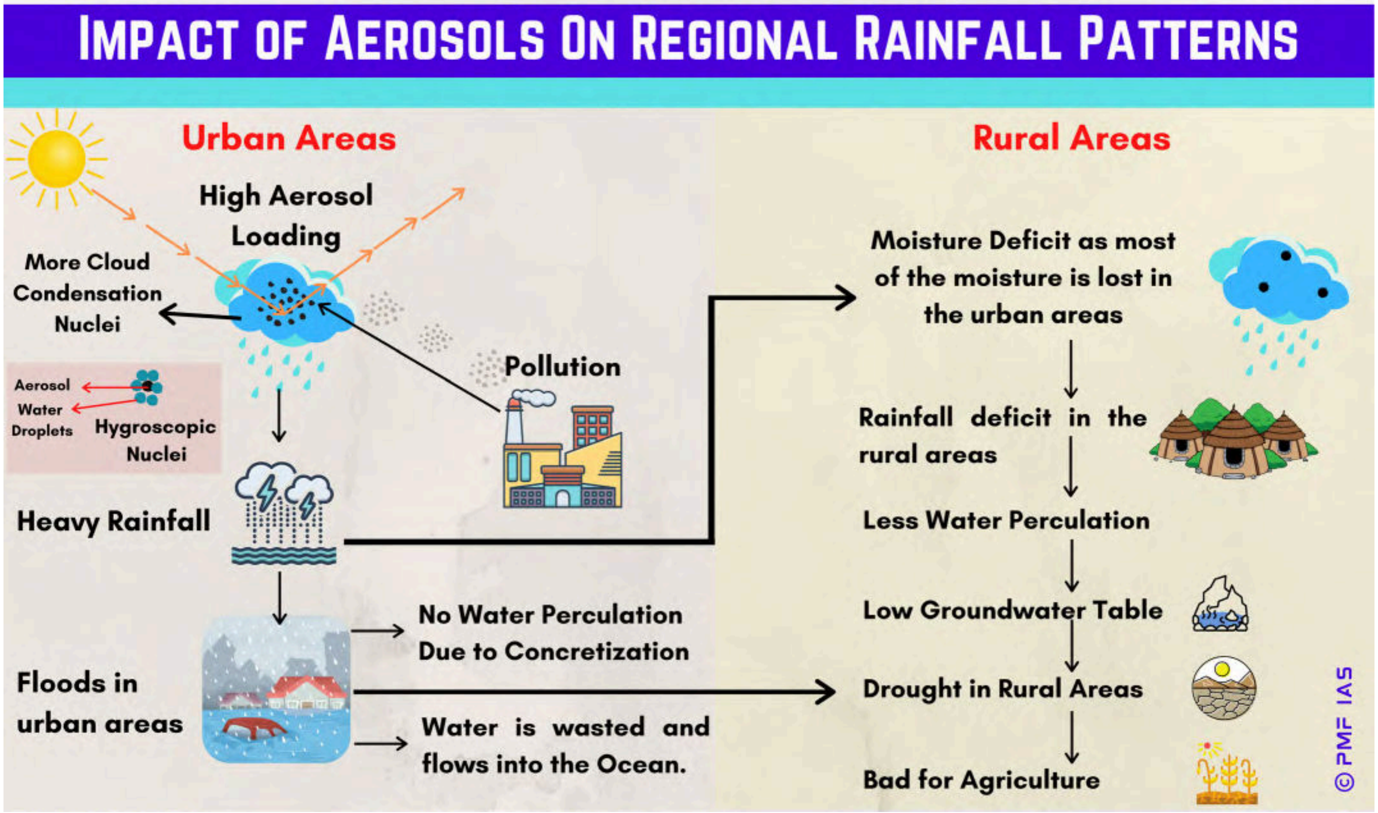

- Aerosol can affect the **radiative balance** of the climate system by
  1. **directly scattering or absorbing sunlight**, or
  2. acting as **cloud condensation nuclei** & ice nuclei & thus **modify the optical properties** as well as **lifetimes of clouds**.
- **Aerosols** lead to **enhancement or suppression** of the Indian summer monsoon rainfall depending on
  - ✓ their duration & scale along with their **tendency to scatter sunlight** directly back into space, or

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✓ by **changing the size of cloud particles**, thus negatively affecting their capacity to absorb sunlight.

- This leads to reduced temperatures over land (due to smog), resulting in **weaker land-sea temperature gradient,** which is an essential force required to pull the monsoon circulation from ocean to land.

17.5.3. Asian Tropopause Aerosol Layer (ATAL) – Negatively Affects Indian Monsoon

- **Asian Tropopause Aerosol Layer (ATAL)** covers **South Asia** during the **monsoon season** & has been suspected to have a role in controlling the monsoon precipitation.
- ATAL is formed because of the **convective transport of aerosols** from the lower atmosphere to the **upper troposphere & lower stratosphere (UTLS —** 12–18 km range**)**.
- It is made up of **sulphates** along with **black-carbon, organic aerosols, nitrates** & dust particles.
- **Black carbon** aerosols in ATAL are transported from **North India & East China** during **El Niño**.
- **Sulphate aerosols** are transported from **East-Asia**.
- The increase of these pollutants in the UTLS leads to the thickening & widening of the ATAL.
- The **higher amounts of sulphate aerosols** in the UTLS lead to a **cooling effect of the earth's surface** by scattering incoming solar radiation & **negatively affect the monsoon**.
- While the **El Niño leads to a decrease in rainfall over India, inclusion of aerosols amplifies decrease in rainfall by 17% over the central India**.

17.5.4. Impact of Aerosols on Regional Rainfall Patterns

- The **incidents of high rainfall events** are **increasing in the urban areas** due to high aerosol loading.

⇨ **High Pollution → High Aerosol Loading → More Cloud Condensation Nuclei → More Precipitation → Floods**.

This is causing a **rainfall deficit** in the **rural areas** **(drought in rural areas & floods in urban areas → less water percolation → lower groundwater table → bad for agriculture).**

17.5.5. Summary

- **Aerosol →** suspension of fine solid particles or liquid droplets in air or another gas

✓ **Natural aerosols →** fog, mist, dust, forest exudates & geyser steam

✓ **Anthropogenic aerosols →** air pollutants like **sulphates, black carbon, dust** & **smoke**

- Aerosols are mainly situated in the low layers of the atmosphere (< 1.5 km).
- **High aerosol loading →** increased incidents of high rainfall events in the foothills of the Himalayan Region → regional disparity in rainfall distribution
- Urban areas → **high pollution → high aerosol loading → more cloud condensation nuclei → more precipitation → floods**
- High rainfall in urban areas → **drought in rural areas & floods in urban areas → less water percolation → lower groundwater table → bad for agriculture**
- Aerosols **affect the radiative balance** by **directly scattering sunlight** or acting as **condensation nuclei**.
- **Aerosols lead to enhancement or suppression** of the Indian summer monsoon rainfall depending on
  1. their **tendency to scatter sunlight** directly back into space, or
  2. by **changing the size of cloud particles**, thus negatively affecting their capacity to absorb sunlight.
- This leads to **weaker land-sea temperature gradient** leading to a **weak monsoon cell**.
- **Asian Tropopause Aerosol Layer (ATAL)** covers **South Asia** during the **monsoon season**.
- **ATAL** is made up of **sulphates, black-carbon, organic aerosols, nitrates** & dust particles.

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- The **higher amounts of sulphate aerosols** lead to a **cooling effect** by scattering incoming solar radiation & **negatively affect the monsoon**.
- **El Niño loaded with aerosols amplifies decrease in rainfall over central India**.

Mains 2015: How far do you agree that the behaviour of the Indian monsoon has been changing due to humanising landscapes? Discuss.

- **Humanising landscapes** refers to the large-scale interaction of humans with the natural environment and the consequent changes brought upon due to such interactions.
- Examples of such interactions include urbanisation, industrialisation, deforestation and desertification, depletion of water resources, etc.
- Consequences of such interactions include rapid increase in concentration of greenhouse gases and aerosols in the atmosphere, global climate change, changes in sea surface temperature, alarming rate of depletion of natural resource, imbalances in the ecosystems, etc.

Impact on Monsoons

- Significant delay in the onset of monsoons, high temporal and special variability, frequent long breaks, abnormally heavy downpours (2018 Kerala Floods; 2015 Chennai floods), etc. are all attributed to anthropogenic climate change.
- The **increasing incidence** of El Nino, La Nina, El Nino Modoki, IOD, due to climate change post-industrial revolution has an overarching effect on the overall mechanism of the Indian Monsoons.
- **Localised pollution (condensation nuclei), deforestation**, on the other hand, cause a **change in regional monsoon patterns**.

High concentration of condensation nuclei disrupts regional patterns of Indian monsoons

- Increase in the number of **condensation nuclei** due to increased availability of pollutants and dust particles will increase condensation of water vapour.
- As the urban atmosphere tends to have greater concentration of condensation nuclei due to vehicular pollution and construction activity, the monsoonal rainfall is disproportionately high in the urban areas.
- Consequently, the agriculture-dependent rural areas tend to receive disproportionately low rainfall.

17.6. Ozone Depletion

- There is a steady decline in the total volume of ozone in **Earth's stratosphere**.
- Much larger decrease in **stratospheric ozone** is observed around **Earth's polar regions**.
- The unique cocktail of the powerful **polar vortex** and **low temperatures** generates **stratospheric clouds** that react with **CFCs** and **destroy the Ozone layer** in the process.
- Ozone holes are most commonly found over the **Antarctic region (experiences strong polar vortex)**.
- They are **comparatively rare & small over the Arctic** (because polar vortex here is comparatively weak and temperatures are relatively high).
- Depletion of ozone is due to increase in **halocarbons** in the atmosphere.
- **Halocarbon:** a compound in which the **hydrogen** of a hydrocarbon is replaced by **halogens**.
- **Halogen:** group of **reactive non-metallic elements** like **fluorine, chlorine, bromine, iodine**, etc.

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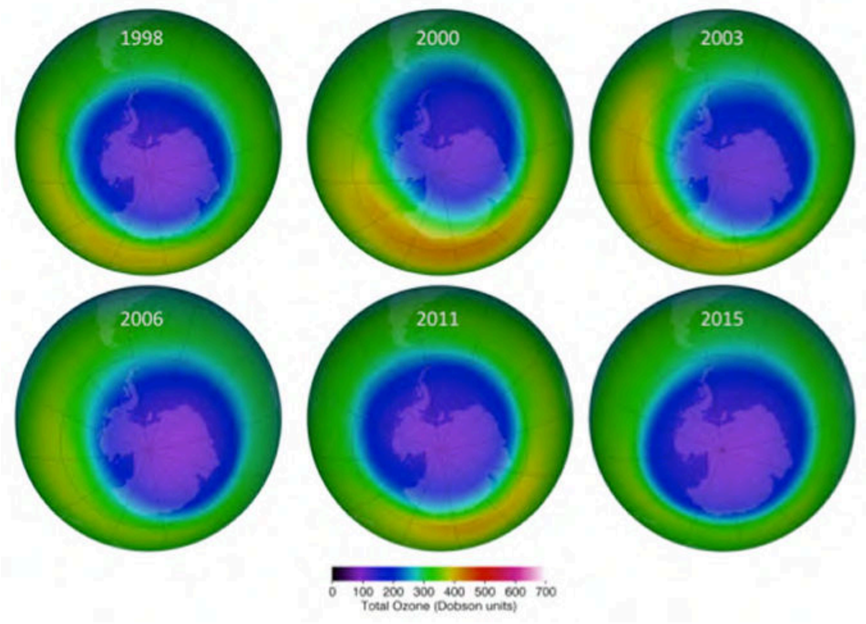
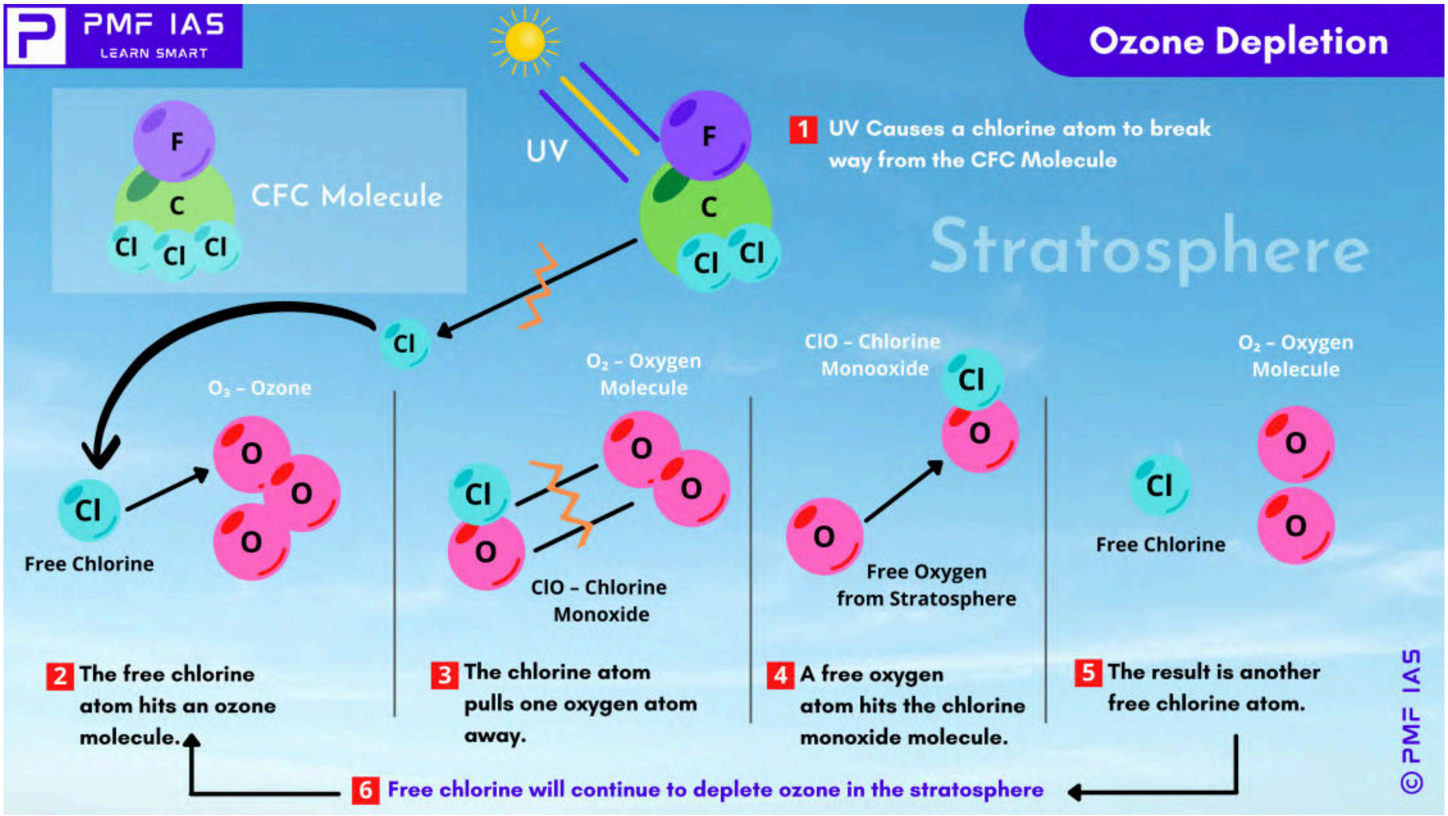


Ozone Hole at the South Pole

17.6.1. Halogen Atoms Like Chlorine Destroy Ozone

- **Photodissociation** (under the influence of sunlight) of **ozone-depleting substances (CFCs, HCFCs, carbon tetra-chloride** and **trichloroethane, freons, halons)** like **halocarbon refrigerants, solvents, propellants**, and **foam-blowing agents** creates **free chlorine atoms** that destroy ozone.



Photodissociation of ozone-depleting substances break O_3 into O_2

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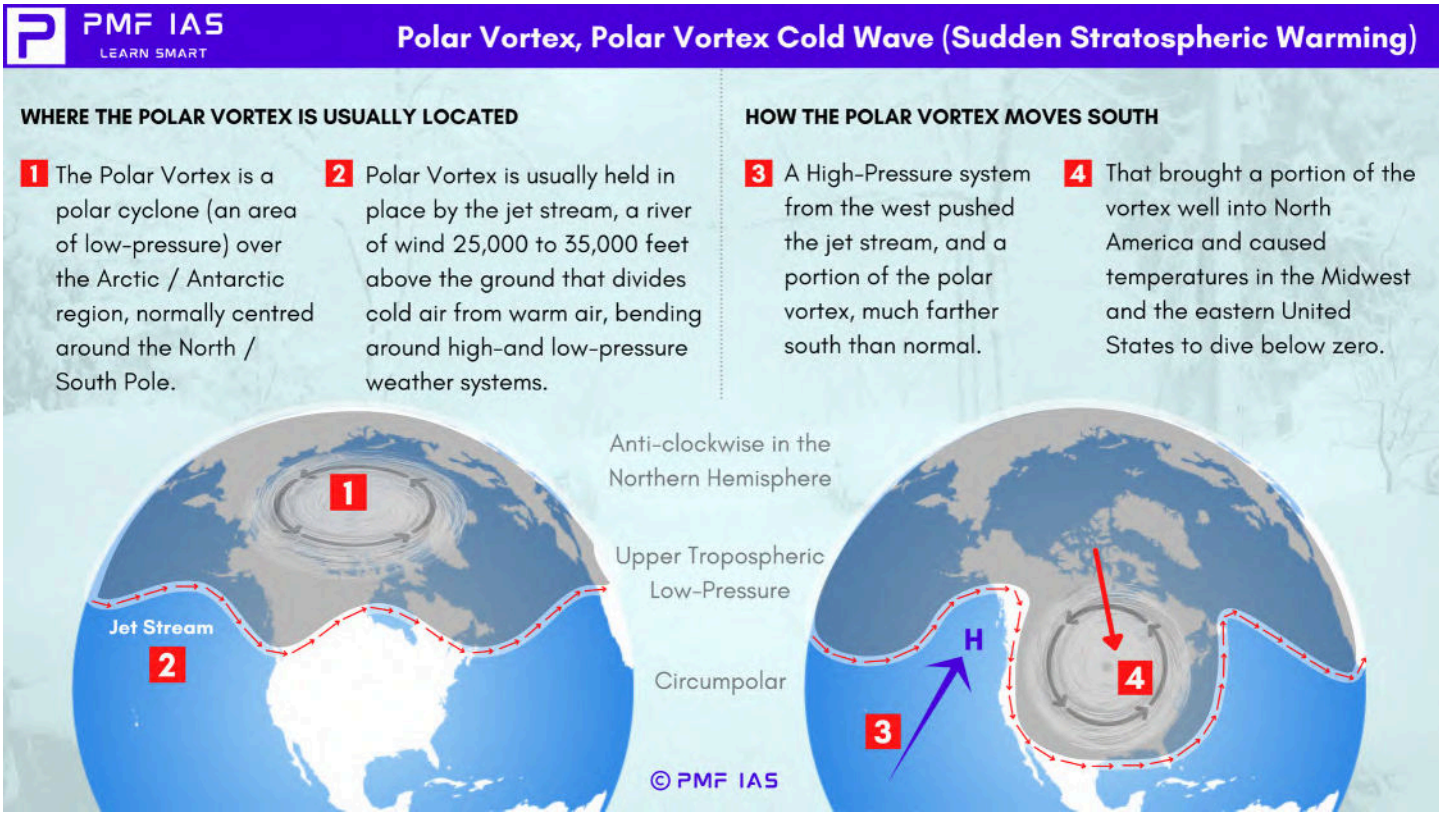

17.6.2. Polar Vortex Acts as the Transportation System for Halogens

- Polar vortex (circumpolar vortex) is a **polar cyclone.**
- Polar cyclones occur in polar regions and can reach up to 2,000 km wide.
- They sometimes extend till the lower levels of **stratosphere** (at poles, the troposphere extends only up to 8-9 km).
- Polar vortex gives rise to **Polar Stratospheric Clouds (PSCs)**.

Polar Stratospheric Clouds (PSCs)

- **Polar Stratospheric Clouds (PSCs)** are **nacreous clouds** that extend from **12-22 km above the surface**.
- Nacreous clouds are **rare clouds** in **frigid regions** of the **lower stratosphere**.

- They are mostly visible within two hours after sunset or before dawn.
- They are bright even after sunset and before dawn because at those heights **there is still sunlight**.
- They are seen mostly during winter at **high latitudes**.
- PSCs or nacreous clouds contain water, **nitric acid** and/or **sulfuric acid**.

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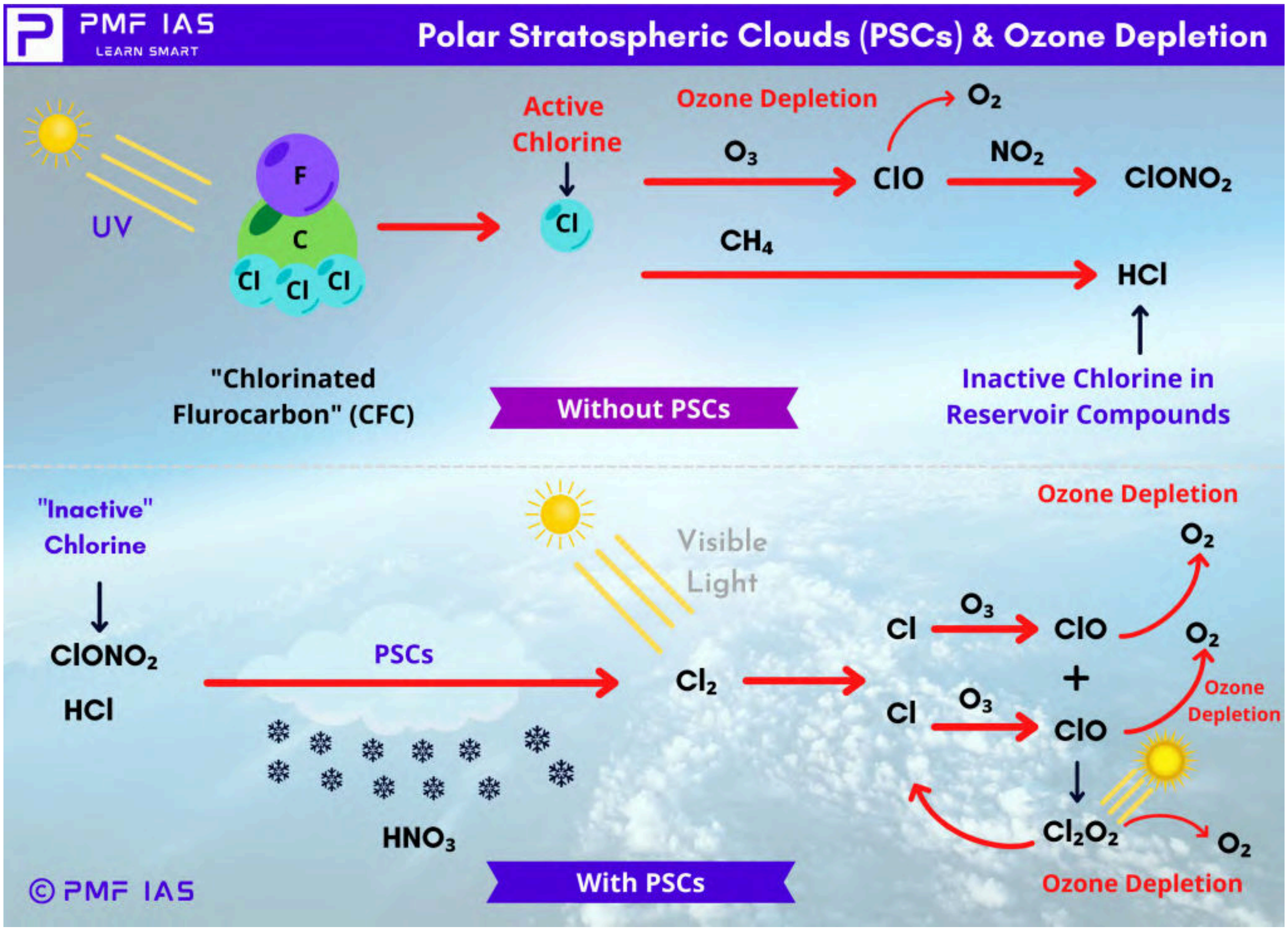
- They are formed mainly during the event of **polar vortex in winter**, **more intense at south pole**.
- The **Cl-catalysed ozone depletion is enhanced in the presence of polar stratospheric clouds**.
- **PSCs** convert **reservoir compounds** into **reactive free radicals (Cl** and **ClO)** thereby significantly **increasing the reactive halogen radicals**. These **free radicals accelerate depletion of ozone**.
- Thus, **polar vortex, in the form of PSCs, accelerate ozone depletion**.



Ozone Depletion is Enhanced by PSCs

The formation of ozone hole in the Antarctic region has been a cause of concern. What could be the reason for ozone depletion at poles?

a) Presence of prominent tropospheric turbulence; and inflow of chlorofluorocarbons
b) Presence of prominent polar front and stratospheric Clouds and inflow of chlorofluorocarbons
c) Absence of polar front and stratospheric clouds; and inflow of methane and chlorofluorocarbons
d) Increased temperature at polar region due to global warming

Explanation:

- Ozonosphere lies at an altitude **between 20 km and 55 km from the earth's surface** and spans the **stratosphere and lower mesosphere**. But the **highest concentration** occurs between **20 km and 30 km**.
- To destroy ozone, **ozone-depleting substances** (ODS) like needs to be **carried up to the lower levels of stratosphere**.
- And the only **weather phenomenon** that can reach to this level are **Polar Vortex** and **towering tropical cumulus clouds**.
- But **towering cumulus clouds do not occur at the poles**.

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Question: The formation of ozone hole in the Antarctic region has been a cause of concern. What could be the reason for ozone depletion at poles?

- Presence of prominent tropospheric turbulence: they do not reach the stratosphere.
- Presence of prominent polar front: essential to keep polar vortex in its place. Polar vortex gives rise to stratospheric Clouds.
- Presence of **stratospheric Clouds**: they have the necessary ingredients (**nitric acid** and/or **sulfuric acid**) to amplify ozone depletion.
- Absence of polar front and stratospheric clouds: polar vortex slips into the temperate region.
- Inflow of methane: **methane (CH_4) is not in the list of ozone-depleting substances**.
- It does not contain a halogen like chlorine, bromine, fluorine, etc. But it reacts with halogens to create **reservoir compounds**.
- Increased temperature at polar region due to global warming: this does not have any direct impact on ozone depletion at the poles.

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18. Prevention and Control of Air Pollution

18.1. Control of Industrial Pollution

- Industrial pollution can be greatly reduced by:
  - ✓ use of cleaner fuels such as **liquefied natural gas (LNG)** in power plants, fertiliser plants etc. which is cheaper in addition to being environmentally friendly.
  - ✓ employing environment-friendly industrial processes so that emission of pollutants and hazardous waste is minimized.
  - ✓ installing devices which reduce the release of pollutants.
- Devices like filters, **electrostatic precipitators, inertial collectors, scrubbers, gravel bed filters or dry scrubbers** are described below:

18.1.1. Filters

- Filters remove **particulate matter** from the gas stream.
- Baghouse filtration system is the most common one and is made of cotton or synthetic fibres (for low temperatures) or glass cloth fabrics (for higher temperature up to 290^0 C).

18.1.2. Electrostatic precipitators (ESP)

- Electrostatic precipitation can remove over **99 per cent particulate matter** present in the exhaust.
- In electrostatic precipitation, emanating **dust is charged with ions**, and the **ionised particulate matter is collected on an oppositely charged surface**.

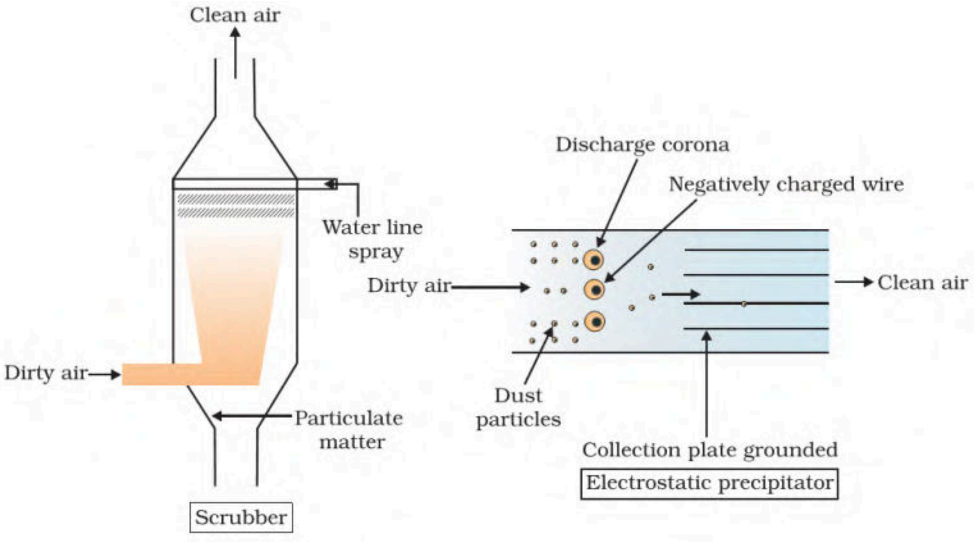

Figure 16.1 Electrostatic precipitator

Working

- An electrostatic precipitator has electrode wires that are maintained at several thousand volts, which produce a **corona** that releases **electrons**.
- These **electrons attach to dust particles** giving them a net negative charge.
- The collecting plates are grounded (relatively positive charge) and **attract the charged dust particles**.
- The velocity of air between the plates must be low enough to allow the dust to fall.

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- The particles are removed from the collection surface by occasional shaking or by rapping the surface.
- ESPs are used in boilers and furnaces, of **thermal power plants, cement factories, steel plants,** etc.

18.1.3. Inertial collectors

- It works on the principle that inertia of SPM (suspended particulate matter) in gas is higher than its **solvent** and as inertia is a function of the mass of the particulate matter, this device collects heavier particles more efficiently (**centrifugation** is the technique).
- '**Cyclone**' is a common inertial collector used in gas cleaning plants.

18.1.4. Scrubbers

- Scrubbers are **wet collectors**. They remove **aerosols** from a stream of gas either by collecting wet particles on a surface followed by their removal or else the particles are wetted by a scrubbing liquid.
- The particles get trapped as they travel from supporting gaseous medium across the interface to the liquid scrubbing medium. (this is similar to mucus in trachea trapping dust)
- A scrubber can remove gases like **sulphur dioxide**.

18.1.5. Catalytic converter

- Catalytic converters, having **expensive metals** namely **platinum-palladium** and **rhodium** as the catalysts, are fitted into **automobiles** for reducing the emission of poisonous gases.
- As the exhaust passes through the catalytic converter,
  - ✓ **unburnt hydrocarbons** are converted into **carbon dioxide** and **water**, and
  - ✓ **carbon monoxide** and **nitric oxide** are changed to **carbon dioxide** and **nitrogen gas**, respectively.
- Motor vehicles equipped with catalytic converter should use **unleaded petrol** because the **lead in the petrol inactivates the catalyst**.

Apart from the use of the above-mentioned devices, other control measures are:

- ✓ increasing the height of chimneys.
- ✓ closing industries which pollute the environment.
- ✓ shifting of polluting industries away from cities and heavily populated areas.
- ✓ development and maintenance of a green belt of adequate width.

18.1.6. Pollution Index to Control Industrial Pollution

- Based on a study jointly carried out by the **CPCB** and **SPCB** in 2009-10, **industrial clusters (sectors)** were notified as **Polluted Industrial Areas (PIAs)**.
- MoEFCC has developed the criteria of categorization of industrial sectors based on the **Pollution Index** which is a function of the emissions (air pollutants), effluents (water pollutants), hazardous wastes generated and **consumption of resources**.
- The Pollution Index PI of any industrial sector is a number from 0 to 100 and the increasing value of PI denotes the increasing degree of pollution load from the industrial sector.
- The purpose of the categorization is to ensure that the industry is established in a manner which is consistent with the environmental objectives.
- The criteria of categorization will prompt industrial sectors willing to adopt cleaner technologies, ultimately resulting in generation of fewer pollutants. It also facilitates self-assessment by industries.

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- It enables authorities to take appropriate action when the need arises. For example, NGT can order certain industries to be closed when air pollution reaches a particular level.

Categories of Industrial Sectors Based on Pollution Index

- **Red category (critically polluted):** Industrial Sectors with Pollution Index score of 60+. (60 industries)
- **Orange category (severely polluted):** Pollution Index score of 41 to 59. (83 industries)
- **Green category (other polluted):** Pollution Index score of 21 to 40. (63 industries)
- **White category (practically non-polluting):** Pollution Index score including and upto 20. (36 industries)
- The newly introduced **White category industrial sectors** will **not require Environmental Clearance (EC) and Consent to Operate**. They have to just **intimate SPCB and CPCB**.
- **No Red category of industries shall normally be permitted in the ecologically fragile/protected area**.

Examples of category of industries

- **Red category: Cement, Petrochemicals, pharmaceuticals, sugar, paper and pulp, nuclear power plants, organic chemicals, fertilizers, firecrackers, etc.**
- **Orange category: Coal washeries, glass, paints, stone crushers, aluminium, and copper extraction from scrap.**
- **Green category: aluminium utensils, steel furniture, soap manufacturing and tea processing.**
- **White category: air cooler or air conditioning units, chalk factories, biscuit tray units, etc.**

18.1.7. Coal Gasification

- Gasification is a technological process that can convert any **carbonaceous (carbon-based) raw material** such as coal into fuel gas, also known as **synthesis/synthetic gas (syngas) or producer gas** — **a mixture of Carbon Monoxide** and **Hydrogen**.
- After cleaning, syngas can be used to produce **synthetic natural gas (SNG-methane (CH_4))** or **liquid biofuel such as synthetic diesel**.
- Gasification occurs in a gasifier, generally a **high temperature (>700 °C)/pressure** vessel where **oxygen** (or air) and **steam** are directly contacted with coal causing a series of thermochemical reactions **(without combustion)** to occur that convert the feed to **syngas** and **ash/slag (mineral residues)**.
- Coal gasification provides one of the cleanest and most versatile ways to convert coal into electricity, hydrogen, and other valuable energy products.
- It thus reduces **carbon monoxide, carbon dioxide** and **sulphur dioxide emissions**.
- Similarly, the gasification of waste reduces the need for landfill space, decreases methane emissions and reduces the use of fossil fuels.
- India aims to achieve **100 MT coal gasification target by 2030**.

18.2. Measures Taken to Control Vehicular Pollution in India

- The emission standards for automobiles have been set which if followed will reduce the pollution.
- Standards have been set for the **durability of catalytic converters** which reduce vehicular emission.
- In cities like Delhi, vehicles need to obtain **Pollution Under Control (PUC) certificate** at regular intervals.
- This ensures that levels of pollutants emitted from vehicles are not beyond the prescribed legal limits.
- To reduce the emission of **sulphur dioxide, sulphur content in diesel has been reduced to 0.05%**.
- Earlier **lead** in the form of **tetraethyl lead** was added in the petrol to **raise octane level** for the **smooth running** of engines. Addition of **lead in petrol** has been **banned** to prevent the emission of lead particles.
- Usage of alternative fuels like **CNG in public transport vehicles is made mandatory** in cities like Delhi.

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- All the buses of Delhi are converted to run on CNG by the end of 2002.
- CNG burns most efficiently, unlike petrol or diesel, in the automobiles and very little of it is left unburnt.
- Moreover, **CNG is cheaper than petrol or diesel**, cannot be siphoned off by thieves and **cannot be adulterated like petrol or diesel**.
- The main problem with switching over to CNG is the **difficulty of laying down pipelines to deliver** CNG through distribution points/pumps and ensuring uninterrupted supply.
- Simultaneously parallel steps taken in Delhi for reducing vehicular pollution include phasing out of old vehicles, **use of unleaded petrol**, **use of low-sulphur petrol and diesel**, use of catalytic converters in vehicles, application of stringent pollution-level norms for vehicles, etc.
- More stringent norms for fuels means **steadily reducing the sulphur and aromatics content** in petrol and diesel fuels.
- The goal, according to the roadmap, is to **reduce sulphur to 50 ppm in petrol and diesel and bring down the level of aromatic hydrocarbons to 35 per cent**.

18.2.1. BS VI from 2020

- From April **2017**, BS IV norms are applicable nationwide.
- October 2018: Supreme Court had ordered a **ban on the sale of Bharat Stage IV vehicles from April 1, 2020**.
- The central government had announced the **April 1, 2020, deadline for adopting Bharat Stage VI** emission norms by manufactures.
- However, existing vehicles (BS III, BS IV) will continue to run beyond the cut-off date of 01/04/2020.

Bharat Stage (BS) norms

- The BS norms are instituted by GOI to regulate the emission of air pollutants from motor vehicles.
- The norms were introduced in **2000**.
- The norms limit the release of air pollutants such as **nitrogen oxides, carbon monoxide, hydrocarbons, particulate matter (PM)** and **sulphur oxides** from vehicles using **internal combustion engines**.
- The norms are meant to be adopted by using appropriate fuel and technology.
- As the stage goes up, the control of emissions become stricter.
- BS IV and BS VI norms are based on similar norms in Europe called Euro 4 and Euro 6.
- As decided initially, BS V would have been rolled out by 2021 and BS VI in 2024, but leapfrog to **BS VI norms by 2020** (**skipping BS V**) had to be done because of the **carbon footprint obligations**.

India's UNFCCC commitments (Intended Nationally Determined Contributions)

- ⇨ **Improve the emissions intensity of its GDP by 33 to 35 per cent by 2030 below 2005 levels.**
- ⇨ **Increase the share of non-fossil fuels-based electricity to 40 per cent by 2030.**
- ⇨ **Enhance forest cover which will absorb 2.5 to 3 billion tons of carbon dioxide by 2030.**

Differences between BS IV and BS VI

- The **extent of sulphur** is the major difference between Bharat Stage IV and Bharat Stage VI norms.
- **BS-IV grade fuels** contain **50 parts per million (ppm) sulphur**
- **BS-VI grade fuel** only has **10 ppm sulphur (10 mg/kg)**.

Advantages of BS VI vehicles and fuel

- **Particulate Matter in diesel cars down by 80 per cent**.
- **Nitrogen oxides from diesel cars by 70 per cent** and **in petrol cars by 25 per cent**.

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- Reduction in sulphur makes it possible to equip vehicles with **better** catalytic converters.
- BS VI also makes **onboard diagnostics (OBD) mandatory** for all vehicles. OBD device informs the vehicle owner or the repair technician how efficient the systems in the vehicle are.
- **RDE (Real Driving Emission)** will be introduced for the first time that will measure the emission in real-world conditions and not just under test conditions.
- Bharat Stage VI norms will also change the way particulate matter is measured. It will now be measured by **number standard** instead of **mass standard**.

Impact

- Compliance required a higher investment in technology to make new vehicles.
- Upgrading vehicles in stock was an additional burden for the manufacturers.
- BS VI-compliant vehicles became expensive.
- BS VI-compliant fuel too became more expensive.

18.2.2. Electric Mobility

- In 2017, the GOI has declared that it wanted India to go **fully electric by 2030**.
- This aim has not yet turned into commitment due to the lack of infrastructure & the financial risks faced by automobile industry in making the transition to EVs.
- After a series of flip-flops over policy on EVs, GOI is pushing aggressively for a switchover from fossil-fuel.
- For the time being, the government's focus is on two- and three-wheelers.
- NITI Aayog has **proposed** to **ban all IC (internal combustion) engine powered two-wheelers and three-wheelers in India starting in 2025 for two-wheelers and in 2023 for three-wheelers**.

Phase-II of the Faster Adoption and Manufacturing of Electric (& Hybrid) Vehicles in India (FAME India) Scheme

- For the promotion of **EVs and hybrid vehicles** in the country, the **Department of Heavy Industry** has notified **Phase-II of the FAME India Scheme**.
- The scheme lays much required thrust on **localization of EV parts**.
- The policy aims to create market for **one million e-2Ws** and **five lakh e-3Ws** in the next three years.
- The scheme offers an **outlay of ₹10,000 crore** to give a fillip to EVs and to set up charging stations.
- The Ministry of Power has already issued guidelines and standards, setting technical parameters for public charging stations that can enable normal and fast charging.

EV Charging Guidelines to Encourage EV Adoption

- To give a boost to Electric Vehicles, Minister of Power has approved amendments in Electric Vehicle Charging Guidelines and Specifications.
- It has been envisaged that in the first phase (i.e. 1-3 years) all **Mega Cities** with population of 4 million plus, **all existing highways connected to/connecting these Mega Cities** will be covered, while in the second phase (3-5 years) big cities like State Capitals, UT headquarters may be covered.
- **Bureau of Energy Efficiency (BEE)**, a **statutory body under Ministry of Power (not MoEF)** has been nominated as the **Central Nodal Agency**.

Electric Vehicle Charging Guidelines and Specifications

- At least one Charging Station to be available in a grid of 3 Km x 3 Km in the cities.
- One charging station at every 25 km on both sides of highways/roads.
- Fast charging station at every 100 kms (one on each side of the highways).

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- Private charging at residences/offices to be managed by DISCOMs.
- The Public Charging Stations (PCS) to be a **de-licensed** activity (anyone can setup a PCS).
- Freedom to Public Charging Stations to install the chargers as per the market requirement.

Tax incentives

- Finance Minister has announced an additional income **tax exemption of ₹1.5 lakh** for purchasers of electric vehicles in Budget 2019-2020.
- She also said that the GST rate on electric vehicles would be lowered to **5% from 12%**.

Scepticism Surrounding Adaptation of Electronic Mobility

- The long-term environmental gains of a global transition to EVs remain unclear.
- India's automobile market is the fourth largest in the world. Installing charging facilities to serve such a vast market will prove much harder than in western countries.
- China has a strategic advantage in a mass switchover, given its **easy access to lithium & cobalt**, and low-cost, high-output automobile batteries. India, on the other hand, will have to depend entirely on imports.

Challenges for the automobile industry

- Automotive sales have plummeted in the recent times due to GTS.
- The situation continues to be made worse by increasing insurance costs, high prices of raw materials and volatile fuel prices.
- The industry has already invested heavily in upgrading to BS-VI (Euro VI) from **BS-IV**.

Will electric vehicles reduce carbon emission?

- As 55% electricity generation in India is primarily using coal, **net reduction in carbon emission will not be much** even if there is large-scale adoption of electric vehicles in India.
- However, electric vehicles will **help reduce pollution in cities** (14 of 20 most polluted cities in terms of harmful particulates (PM 2.5) are in India).

18.2.3. Green Tax on Old Vehicles

- Recently, Government proposed **'green tax' for old petrol, diesel vehicles**.
  - ✓ **Transport vehicles older than 8 years** could be charged Green Tax at **10-25% of road tax**.
  - ✓ **Personal vehicles** to be charged Green Tax after **15 years**.
  - ✓ **Public transport** vehicles, such as city buses, to be charged **lower Green tax**.
  - ✓ **Higher Green tax (50% of Road Tax) for vehicles being registered in highly polluted cities**.
  - ✓ **Differential tax**, depending on fuel (petrol/diesel) and type of vehicle.
  - ✓ **Vehicles used for farming such as tractors and combined harvesters could be exempted**.
  - ✓ **Vehicles running on clean fuel — CNG, LPG, ethanol & strong hybrid — would also be exempted**.
  - ✓ Revenue collected from the Green Tax to be kept in a **separate account** and used for tackling pollution, and for States to set up state-of-art facilities for emission monitoring.
- Based on the principle of **"polluters must pay",** this charge would be levied **when commercial vehicles go for obtaining fresh fitness certificate** and **private vehicles for seeking renewal of registration**.
- **State governments** would be allowed to levy this tax over and above the regular road taxes.
- Currently, similar taxes are levied in Andhra Pradesh, Maharashtra Karnataka, Telangana, UP & Jharkhand.

Polluters Pay Principle

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- The 'polluter pays' principle is the commonly accepted practice that **those who produce pollution should bear the costs** of managing it to prevent damage to human health or the environment.
- For instance, a factory that produces a potentially poisonous substance as a by-product of its activities is usually held responsible for its safe disposal.
- The polluter pays principle is part of a set of broader principles to guide sustainable development worldwide (formally known as the 1992 Rio Declaration).
- When the pollution cost from the release of GHGs is not imposed on emitters, these costs are thus **'externalised' to society**, representing '**market failure**'.
- Society bears these costs as GHGs are emitted into the atmosphere, which is described a '**global commons**' as everyone shares & has the right to use.

18.3. National Clean Air Program (NCAP)

- The Government of India (GOI) launched its National Clean Air Program (NCAP) in 2019.
- NCAP aims to **reduce pollution levels (PM2.5 and PM10) by 20-30% by 2024 in cities**.
- The NCAP will be a **mid-term, five-year action plan** with **2019 as the first year**.
- The NCAP has cited how Beijing has succeeded in reducing PM2.5 by 33.3 per cent in five years.
- The NCAP is working to expand the national air quality monitoring network, build capacity for air pollution management, and strengthen public awareness about the dangers of air pollution.

NGT has Criticised NCAP Plan

- The NCAP plan includes 102 non-attainment cities, across 23 states & UTs, which were identified by the **Central Pollution Control Board (CPCB)** based on their ambient air quality data between 2011 & 2015.
- **Non-Attainment Cities** cover only cities where standards were not consecutively met for five years.
- NGT said the MoEF's plan was against the constitutional mandate under Article 21. **Right to Clean Air** stood recognised as part of **Right to Life** & failure to address air pollution was **denial of Right to Life.**
- NGT said the enforcement of 'Sustainable Development' principle & 'Public Trust Doctrine' required stern measures to be adopted.
- Under the **NCAP, the target was to achieve norms in 10 years** & reduce load to the extent of 35% in first three years with further reduction of pollution later.
- It meant, **for 10 years**, **pollution would remain unaddressed** which was too long period of tolerating violations when clean air was Right to Life.

Other Criticism of NCAP

- It was not clear what type of pollutants, or all pollutants would be reduced.
- The NCAP is **only a cooperative and participatory initiative**.
- This will **not be notified under any Act** to create a firm mandate with a strong legal back up.
- NCAP only mentions that the Central Pollution Control Board (**CPCB**) will execute the programme in consonance with the Air (Prevention and Control of Pollution) Act, 1986.
- 11th and 12th Five Year Plans had taken on board the strategy of National Clean Air Action Plan for all major cities to meet the National Ambient Air Quality Standards.
- But that remained a non-starter as it was not backed by a clear legal mandate and was underfunded.

Q. What are the key features of the National Clean Air Programme (NCAP) initiated by the Government of India? (UPSC CSE Mains 2020 – 250 words).

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18.4. National Air Quality Monitoring Programme

- Central Pollution Control Board (CPCB) has been executing a nationwide programme of ambient air quality monitoring known as **National Air Quality Monitoring Programme (NAMP)**.
- The National Air Quality Monitoring Programme (NAMP) is undertaken
  - ✓ to determine the status and trends of ambient air quality;
  - ✓ to ascertain the compliance of NAAQS;
  - ✓ to identify non-attainment cities;
  - ✓ to understand the natural process of cleaning in the atmosphere; and
  - ✓ to undertake preventive and corrective measures.

18.4.1. National Ambient Air Quality Standards (NAAQS)

- NAAQS is developed by the **Central Pollution Control Board**.

National Ambient Air Quality Standards, as of 2009			
Pollutant (must remember)	**Time Weighted Average**	**Concentration in Ambient Air (numbers not important)**	
		Industrial, Residential, Rural & Other Area	**Ecologically Sensitive Area (notified by GOI)**
1. SO_2, µg/m³	Annual	50	20
	24 hours	80	80
2. NO_2, µg/m³	Annual	40	30
	24 hours	80	80
3. PM_{10}, µg/m³	Annual	60	60
	24 hours	100	100
4. $PM_{2.5}$, µg/m³	Annual	40	40
	24 hours	60	60
5. O_3, µg/m³	8 hours	100	100
	1 hour	180	180
6. Lead (Pb), µg/m³	Annual	0.50	0.50
	24 hours	1	1
7. CO, mg/m³	8 hours	2	2
	1 hour	4	4
8. Ammonia (NH_3), µg/m³	Annual	100	100
	24 hours	400	400
9. Benzene	Annual	5	5
10. Benzopyrene	Annual	1	1
11. Arsenic (As), ng/m3	Annual	6	6
12. Nickel (Ni), ng/m3	Annual	20	20

18.4.2. SAFAR System for Monitoring Air Pollutants

- The **System of Air Quality and Weather Forecasting and Research (SAFAR)** is a national initiative introduced by the **Ministry of Earth Sciences (MoES)** **(not MoEF)**.

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- SAFAR system will measure the air quality of a **metropolitan city**, by measuring the overall pollution level and the location-specific air quality of the city.
- It also monitors all weather parameters like temperature, rainfall, humidity, wind speed, and wind direction, **UV radiation**, and solar radiation.
- The network has multiple air quality monitoring stations in each city, equipped with real-time, continuous monitors for a range of pollutants including PM2.5 (**PM1 included**) and PM10.
- The system is indigenously developed by the **Indian Institute of Tropical Meteorology (IITM), Pune** and is operationalized by the **India Meteorological Department (IMD)**.
- It has a giant true colour LED display that gives out real-time air quality index on a 24x7 basis with color-coding (along with 72 hours advance forecast).
- The ultimate objective of the project is to **increase awareness** among the public regarding the air quality in their city.
- SAFAR is an integral part of **India's first Air Quality Early Warning System** operational in Delhi.
- Pollutants monitored under SAFAR System include:

1. **PM2.5,**
2. **PM10,**
3. **Ozone,**
4. **Carbon Monoxide (CO),**
5. **Nitrogen Oxides (NO_x),**
6. **Sulphur Dioxide (SO_2),**
7. **Benzene (**found in **crude oil**. It's used to make **plastics, resins, synthetic fibres, rubber lubricants**, etc.
   - As a **Volatile Organic Compound, benzene** reacts with other air pollutants to form **ground levels ozone** which can damage crops (in the form of **smog**) and materials),
8. **Toluene (methylbenzene —** used in **paint thinners** & as **octane booster in gasoline engines),**
9. **Xylene (dimethylbenzene** — used as a **solvent in printing, rubber,** and **leather industry**), and
10. **Mercury**

Degrees of Air Pollution

SAFAR AQI Scale		World AQI Scale	
Good	0-50	Good	0-50
Satisfactory	51-100	Satisfactory	50-100
Moderate	100-200	Unhealthy**	100-150
Poor	201-300	Unhealthy	150-200
Very Poor	301-400	Very Unhealthy	200-300
Severe	401-500	Severe	Over 300

18.4.3. National Air Quality Index (AQI)

- It was launched by the Environment Ministry in April 2015 under **'Swachh Bharat'.**
- It helps the common man to judge the air quality within his vicinity.
- There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe.
- The AQI will consider **eight pollutants** (**PM10, PM2.5, NO_2, SO_2, CO, O_3, NH_3, and Pb**).

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Q. In the cities of our country, which among the following atmospheric gases are normally considered in calculating the value of Air Quality Index? (2016)

1) Carbon dioxide
2) Carbon monoxide
3) Nitrogen dioxide
4) Sulphur dioxide
5) Methane

Select the correct answer using the code given below.

a) 1, 2 and 3 only
b) 2, 3 and 4 only
c) 1, 4 and 5 only
d) 1, 2, 3, 4 and 5

Answer: b) 2, 3 and 4 only

18.5. Measures Taken to Control Air Pollution in the National Capital Region

- The **Environment Pollution (Prevention and Control) Authority** is a **Supreme Court-appointed body**.
- It was notified in 1998 by Environment Ministry under **Environment Protection Act, 1986**.
- Its initial mandate was to ensure that Delhi's bus & auto fleet moves entirely to CNG.
- Its mandate now is to prevent and control environmental pollution in the National Capital Region.
- It is also mandated to enforce **Graded Response Action Plan (GRAP)** in NCR as per the pollution levels.

18.5.1. Graded Response Action Plan (GRAP)

- GRAP works only as an **emergency measure**.
- As such, the plan does not include action by various state governments to be taken throughout the year to tackle industrial, vehicular & combustion emissions.
- The plan is **incremental in nature** — therefore, when the air quality moves from 'Poor' to 'Very Poor', the measures listed under **both sections** must be followed.
- GRAP has been successful in doing two things that had not been done before —
  - ✓ **Creating a step-by-step plan** for the entire Delhi-NCR region, &
  - ✓ **Getting on board several agencies:** all pollution control boards, industrial area authorities, municipal corporations, regional officials of the India Meteorological Department, & others.
- The plan requires action & coordination among 13 different agencies in Delhi, Uttar Pradesh, Haryana & Rajasthan (NCR areas).
- Before the imposition of any measures, EPCA holds a meeting with representatives from all NCR states.

Actions Under GRAP

Severe+ or Emergency (PM 2.5 over 300 µg/cubic metre or PM10 over 500 µg/cu. m. for 48+ hours)

- Stop entry of trucks into Delhi (except essential commodities)
- Stop construction work.
- Introduce odd/even scheme for private vehicles & minimise exemptions.

Severe (PM 2.5 over 250 µg/cu. m. or PM10 over 430 µg/cu. m.)

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- Close brick kilns, hot mix plants, stone crushers.
- Maximise power generation from natural gas to reduce generation from coal.
- More frequent mechanised cleaning of road & sprinkling of water.

Very Poor (PM2.5 121-250 μg/cu. m. or PM10 351-430 μg/cu. m.)

- Stop use of diesel generator sets.
- Enhance parking fee by 3-4 times.
- Apartment owners to discourage burning fires in winter by providing electric heaters during winter.

Moderate to poor (PM2.5 61-120 μg/cu. m. or PM10 101-350 μg/cu. m.)

- Heavy fines for garbage burning.
- Close/enforce pollution control regulations in brick kilns & industries.
- Mechanised sweeping on roads with heavy traffic & water sprinkling.
- Strictly enforce ban on firecrackers.

Other measures

- NGT ordered a ban on old diesel and petrol vehicles within the city.
- Open burning has been largely curtailed.
- Completion of the eastern and western peripheral expressways for vehicles not destined for Delhi.

Has GRAP helped?

- The biggest **success** of GRAP has been in fixing accountability & deadlines.
- For each action to be taken under a particular air quality category, executing agencies are clearly marked.
- Coordination among as many as 13 agencies from four states is simplified to a degree because of the clear demarcation of responsibilities.
- Three major policy decisions that can be credited to EPCA & GRAP are
  - ✓ the closure of the thermal power plant at Badarpur,
  - ✓ bringing BS-VI fuel to Delhi before the deadline set initially, &
  - ✓ the ban on **Peat coke** as a fuel in Delhi-NCR.
- The EPCA, headed by retired IAS officer & including members from the Centre for Science & Environment, was constituted in 1998 by the Supreme Court.
- The body continues to monitor pollution, & assists the Supreme Court in several pollution-related matters.

Measures to Reduce Stubble Burning

PUSA Decomposer

- Scientists at Indian Agriculture Research Institute (IARI) have invented PUSA Decomposer.
- It will be **used for the speedy decomposition of stubble** in the national capital and nearby states.
- In one capsule, a farmer can make 25 litres of liquid substance.
- After making the liquid, he has to add jaggery and gram flour in it and has to sprinkle that liquid on the stubble, after which it would bio-degrade in 20 days.

Super Stubble Management Systems (Super SMS) and Happy Seeders

- Punjab government provided 50,000+ subsidised stubble management machines.
- **Super SMS** helps in **chopping the stubble and spreading that evenly**.
- The **Happy Seeder** helps in **direct showing of wheat without clearing the stubble**.

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- However, 50,000 machines cannot cover even half the area due to short window period between paddy harvesting and wheat sowing (1st week of Oct to 2nd week of Nov).
- Farmers in Punjab have been demanding cash incentive as 'cost compensation' to stop burning crop residue.

18.5.2. Smog Towers

- In November 2020, the Supreme Court had directed the government to prepare a plan to install 'smog towers' across the capital to deal with air pollution.
- Smog towers are structures designed to work as large-scale air purifiers.
- They are fitted with multiple layers of air filters, which clean the air of pollutants as it passes through them.
- The filters installed in the tower will use **carbon nanofibers** as a major component.
- The Supreme Court had further ordered that **anti-smog guns** should be mandatory in projects that require **environmental clearance (EC)** and have a built-up area of over **20,000 square metres**.
- As per the SCs directions, 47 large projects in Delhi had to have these guns installed.

18.6. Emissions Trading Scheme (ETS) by Gujarat for Trading in Particulate Matter

- Gujarat government launched Emissions Trading Scheme (ETS) for trading in **particulate matter emissions**.
- While trading mechanisms for pollution control do exist, **none** of them is for **particulate matter** emissions.
- For example,
  - ✓ the Clean Development Mechanism **(CDM – Kyoto Protocol)** allows trade in '**carbon credits**';
  - ✓ the **European Union's Emission Trading System** is for **GHG emission**; and
  - ✓ India has a scheme run by the **Bureau of Energy Efficiency** that enables **trading in energy units**.
- Launched in **Surat**, the ETS scheme is not only aimed at reducing pollution, but also at **minimizing the cost of compliance** for the industry.
- **Nobel Laureates Abhijit Banerjee** and Esther Duflo's **Abdul Latif Jameel Poverty Action Lab (J-PAL)** is one of the primary agencies working on the novel Emission Trading Scheme (ETS).

18.6.1. How does Emission Trading Scheme (ETS) work?

- The Gujarat Pollution Control Board (GPCB) **sets a cap on the total emission load** for all industries.
- Various industries can buy and sell the ability to emit particulate matter, by trading permits (in kilograms) under this cap. For this reason, ETS is also called a cap-and-trade **market**.
- These permits are a way to allow industries to buy some time and make investments in clean technologies.

Why was Surat chosen for the scheme?

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- Surat is facing severe pollution and industries in Surat have already installed **Continuous Emission Monitoring Systems**, which makes it possible to estimate the mass of particulate matter being released.

18.7. Pradhan Mantri Ujjwala Yojana to reduce Household Pollution

- In 2015, India's annual air pollution level was **55 micrograms per cubic metre** of fine particulate matter.
- Levels in **New Delhi** often soared beyond **300 micrograms per cubic metre**.
- Replacing biomass with **cleaner fuels like LPG** would cut India's average annual air pollution to 38 micrograms per cubic metre.
- This is just below the National Ambient Air Quality **standard** of **40 micrograms per cubic metre** and above the **WHO standard of 10 micrograms per cubic metre**.
- In 2016, **Pradhan Mantri Ujjwala Yojana** was instituted by **Ministry of Petroleum & Natural Gas** for providing **LPG connections** to **women** from **Below Poverty Line (BPL)** households.
- LPG cylinders are now used by 89% households in India (it was 56.2% on April 1, 2015)
- Northern and southern states have the highest LPG coverage ratio (more than 99%).
- Western states have 81.9% and most North-Eastern states have less than 80% coverage.
- The worst among major states are Jharkhand (65.4%), Bihar (67%) and Odisha (66.9%).

18.7.1. Prevention and Control of Indoor Air Pollution

- Use of wood and dung cakes should be replaced by cleaner fuels such as biogas, LPG or electricity.
- The use of solar cookers must be encouraged.
- Species of trees such as baval (Acacia nilotica) which are least smoky should be used.
- Charcoal is a comparatively cleaner fuel.
- Indoor pollution due to the decay of exposed kitchen waste can be reduced by covering the waste properly.
- Segregation of waste, pre-treatment at the source, sterilisation of rooms will help.

18.8. Other Measures

18.8.1. Green crackers

- In 2019, the Supreme Court mandated the use of green crackers for Diwali.
- Traditionally, firecrackers have been made with **barium nitrate, antimony** and a range of metals.
- The SC had banned the use of **barium nitrate**, a key pollutant in crackers.
- The **National Environmental Engineering Research Institute (NEERI)**, a part of the **CSIR**, was asked to facilitate the development of green crackers.
- NEERI substituted **barium nitrate** with **potassium nitrate** and **zeolite** to reduce PM10 and PM2.5 by 30%.

⇨ 90% of India's crackers are manufactured in **Sivakasi, Tamil Nadu**.

18.8.2. Government Initiatives to Reduce SO_2 emissions

- In 2015, the MoEF introduced SO_2 emission limits for **coal power stations**.
- The initial deadline of December 2017 for the installation of **flue-gas desulfurization units** was missed.
- Though the deadline was extended till **2022**, as of June 2021 most of the power plants are operating without compliance to standards."
- The total capital expenditure required for installing pollution-control clean technology in existing and new plants is estimated to be at least ₹73,000.

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Flue-gas desulfurization (FGD) systems

- **Lime** is used to remove acidic gases, particularly **sulphur dioxide (SO_2)** and **HCl**, from flue gases (gases flowing out of vertical exhaust pipes).
- Flue-gas desulfurization (FGD) may involve **wet scrubbing** or **dry scrubbing**. Lime is used in both.
- In wet FGD systems, flue gases are brought in contact with a liquid or solid slurry absorbent.
- The sulphur dioxide dissolves in or reacts with the absorbent & becomes trapped in as wet **calcium sulphite**. The sulphite can be converted to **gypsum** (used in cement production).
- In dry FGD scrubbing, lime is injected directly into flue gas to remove SO_2 and HCl from low-sulphur fuels.

18.9. National & International Measures to Regulate Ozone Depleting Substances

18.9.1. Vienna Convention for the Protection of the Ozone Layer

- The Vienna Convention for the Protection of the **Ozone Layer (Vienna Convention)** was agreed in **1985**.
- It established **global monitoring and reporting on ozone depletion**.
- It also created a **framework for the development of protocols** for taking **more binding action**.

Montreal Protocol on Substances that Deplete the Ozone Layer

- The **Montreal Protocol** under the **Vienna Convention** was agreed in **1987**.
- It facilitates **global cooperation in reversing the rapid decline in atmospheric concentrations of stratospheric ozone (good ozone)**.
- Under the protocol **countries agreed to phase out the production and consumption of certain chemicals that deplete ozone**.
- Phase out of these substances is required by **specific deadlines**.
- The **Vienna Convention and its Montreal Protocol** are the **first and only global environmental treaties** to achieve **universal ratification**, with **197 parties**.
- As a result of the international agreement, the ozone hole in Antarctica is **slowly recovering**.
- Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.

Compliance

- 40 to 60 per cent of total global **CFC-11 (Trichlorofluoromethane)** emissions are coming from China.
- CFC-11 is a **chlorofluorocarbon,** which are outlawed for almost all uses by the 1987 **Montreal Protocol**.
- Being the signatory to the Montreal Protocol, China agreed to phase out production of CFC-11 in 2010.
- The Chinese foam manufacturers have been using CFC-11 illegally to save on the higher cost of alternatives, such as **hydrochlorofluorocarbons** like **HCFC-141b**, which is to be phased out in China by 2026.
- Reduction in the atmospheric concentration of CFC-11 has made the second-largest contribution to the decline in the total atmospheric concentration of ozone-depleting chlorine since the 1990s.
- But this gas **(CFC-11) still contributes one-quarter of all chlorine reaching the stratosphere**.

Q. Which one of the following is associated with the issue of control and phasing out of the use of ozone-depleting substances?

a. Bretton Woods Conference
b. Montreal Protocol
c. Kyoto Protocol
d. Nagoya Protocol

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Explanation:

- **Bretton Woods Conference** established the **International Bank for Reconstruction and Development (IBRD)** and the **International Monetary Fund (IMF)**.
- **Montreal Protocol** is an international treaty to protect the ozone layer by phasing out the production of ozone depleting substances. It is legally binding.
- **Kyoto Protocol** implemented the objective of the UNFCCC to **fight global warming by reducing GHG concentrations** in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system". It is binding on the parties.
- **Nagoya Protocol** is an agreement to the 1992 **Convention on Biological Diversity (CBD)** on "Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization".

Answer: b)

18.9.2. Kigali Amendment to Montreal Protocol 2016

- In the 28th meeting of the Parties (2016) to the Montreal Protocol, negotiators from 197 nations have signed an agreement to amend the Montreal Protocol in **Kigali (capital city of Rwanda)**.
- Kigali Amendment to the Montreal Protocol aims to phase out the use of potent greenhouse gases called **hydrofluorocarbons**, which are used widely in ACs.
- Unless substituted, ACs alone could cause 0.4 °C of additional warming by the end of the century.
- ACs greatly exacerbate **Urban Heat Island effect** making cities inhospitable, especially for the poor.
- The parties are expected to **reduce the manufacture and use of Hydrofluorocarbons (HFCs) by roughly 80-85% from their respective baselines, till 2045**.
- This phase down is expected to arrest the global average temperature rise up to **0.5 °C by 2100**.
- It is a **legally binding** agreement between the signatory parties with non-compliance measures.
- It came into effect from 1st January 2019.

Hydrofluorocarbons (HFCs)

- **Hydrofluorocarbons (HFCs)** are used since as an alternative to **CFCs** and **HCFCs**.
- HFCs **do not contribute to ozone depletion**.
- However, they are **potent greenhouse gases** with **high global warming potential**.

India's position

- India has agreed on a lenient schedule as it consumes only **3% of HFCs** as compared to the other nations like the **USA (37%)** and **China (25%)**.

18.9.3. HFO Alternatives to HFCs

- HFO stands for **hydrofluoro olefin**.
- HFO refrigerants are composed of **hydrogen, fluorine** and **carbon atoms**, but contain at least **one double bond** between the carbon atoms.

Comparison: CFCs, HCFCs, HFCs & HFOs

Fluorochemical	Ozone Depleting Potential	Global Warming Potential
Chlorofluorocarbons (CFCs)	**High**	**High**
Hydrochlorofluorocarbons (HCFCs)	**Low**	**High**

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Hydrofluorocarbons (HFCs)	**Zero**	**High**
Hydrofluoro Olefin (HFOs)	**Zero**	**Very Low**

18.9.4. The Ozone Depleting Substances (ODS) Rules

- The rules are framed under the jurisdiction of **Environment (Protection) Act**.
- These Rules set the deadlines for phasing out of various ODSs, besides **regulating production, trade import and export** of ODSs and the product containing ODS.
- These Rules **prohibit the use of CFCs** in manufacturing various products beyond 1st January 2003 except in **metered dose inhaler** and for other medical purposes.
- Similarly, **use of halons is prohibited** after 1st January 2001 except for essential use.
- Other ODSs such as **carbon tetrachloride** and **methylchoroform** and CFC for **metered dose inhalers** can be used upto 1st January 2010.
- Further, the use of **methyl bromide** has been allowed upto 1st January 2015.
- Since **HCFCs are used as interim substitute to replace CFC, these are allowed up to 1st January 2040**.

India phases out of ozone depleting HCFC-141b

- India has completely phase out of **Hydrochlorofluorocarbon (HCFC)-141 b**, which is one of the most potent ozone depleting chemicals after Chlorofluorocarbons (CFCs).
- HCFC-141b is used in foam manufacturing in the production of rigid **polyurethane (PU) foams**.
- The polyurethane foam sector has links with important economic sectors related to buildings, cold storages and cold chain infrastructure, automobiles, commercial refrigeration, etc.
- HCFC-141b is prohibited from 1st January 2020 under **Ozone Depleting Substances (Regulation and Control) Amendment Rules, 2019** issued under the **Environment (Protection) Act, 1986**.
- HCFC-141b is not produced in the country and all the domestic requirements are **met through imports**.
- With the **Amendment Rules, 2019**, the import of HCFC-141 b is completely prohibited.
- That means India has **completely phased out the important ozone depleting chemical HCFC-141 b**.
- The complete phase out of HCFC 141b from the country in foam sector is among the first at this scale in Article 5 parties (developing countries) under the **Montreal Protocol**.

Closure of Hindustan Fluorocarbons Limited (HFL)

- GOI has approved the closure of Hindustan Fluorocarbons Limited (HFL) recently.
- HFL is a subsidiary of Hindustan Organic Chemicals Ltd., under Department of Chemicals & Petrochemicals.
- HFL is engaged in the manufacture of **Chloro Di Fluoro Methane (HCFC-22 or CFM-22)** and also uses the same for conversion to **Poly Tetra Fluoro Ethylene (PTFE)**.
- Under the provisions of Montreal Protocol on phasing out of ozone depleting substances, HFL's HCFC-22 present production quota is not sufficient for the plant to operate.

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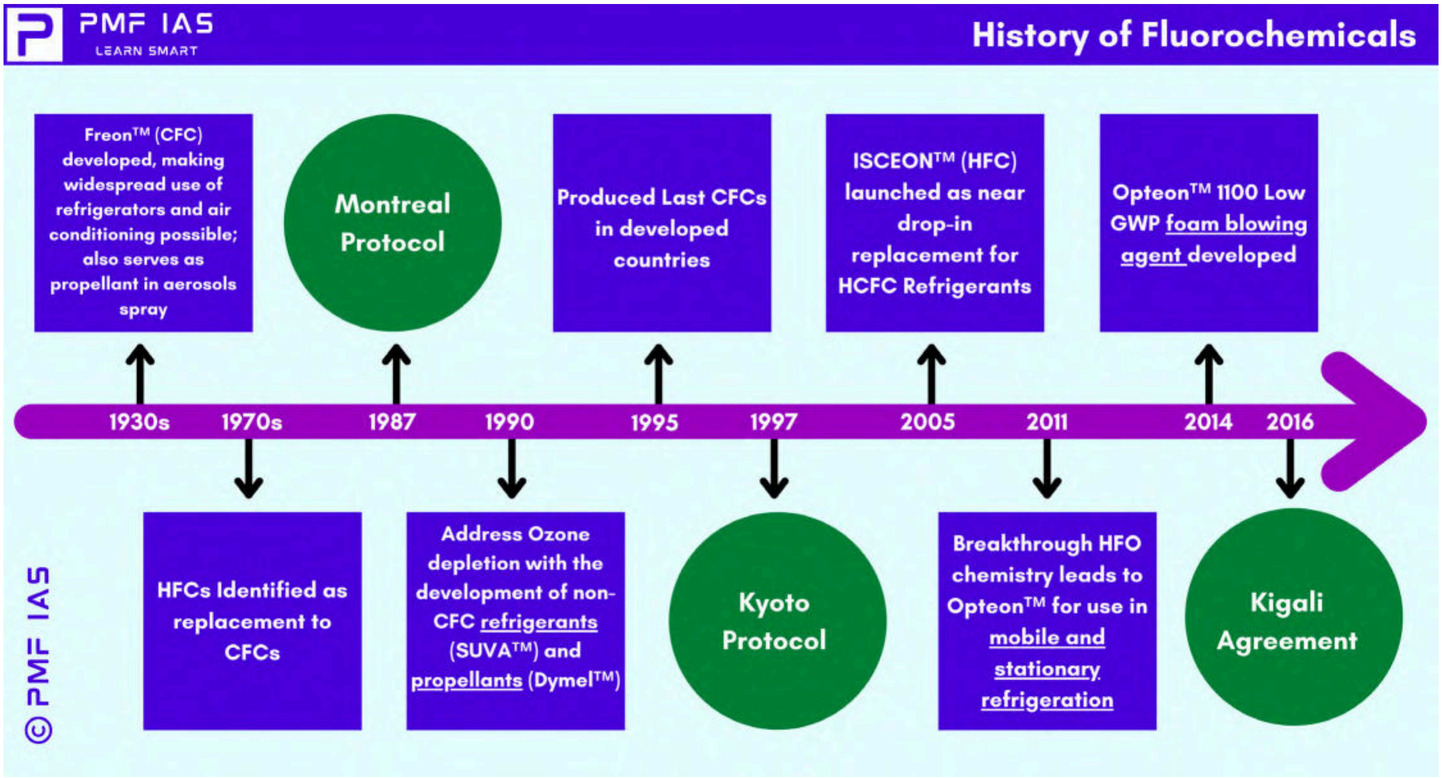

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19. Water Pollution and Marine Pollution

- Water pollution is the addition/presence of undesirable substances to/in water such as organic, inorganic, biological, **radiological, heat**, which degrades the quality of water so that it becomes unfit for use'.
- Natural sources of pollution of water are soil erosion, leaching of minerals from rocks (due to natural solubility and solubility triggered by **acid rain**) and decaying of organic matter.

Point and Non-Point Sources of Pollution

- When pollutants are discharged from a **specific location** such as a drainpipe carrying industrial effluents discharged directly into water body it represents point source pollution.
- In contrast, non-point sources include discharge of pollutants from **diffused sources or from a larger area** such as runoff from agricultural fields, grazing lands, construction sites, abandoned mines and pits, etc.

19.2. Causes of Water Pollution

19.2.1. Sewage Water

- Sewage water includes discharges from houses and other establishments. It contains human and animal excreta, food residues, cleaning agents, detergents, etc.
- Domestic and hospital sewage contain many undesirable pathogenic microorganisms.

Dissolved Oxygen (DO)

- Presence of **organic** and **inorganic wastesdecreases the dissolved oxygen content** of the water.
- Water having DO content below 8.0 mg/L may be considered as contaminated.
- Water having DO content below. 4.0 mg/L is considered to be highly polluted.
- DO content of water is important for the survival of aquatic organisms.
- Multitude of factors like **surface turbulence, photosynthetic activity, O_2 consumption by organisms** and **decomposition of organic matter** determine the amount of DO present in water.
- The **higher amounts of waste increase the rates of decomposition and O_2consumption** thereby **decreases the DO content of water**.

Biological Oxygen Demand (BOD)

- Water pollution by **organic wastes**is measured in terms of **Biochemical Oxygen Demand (BOD)**.
- BOD is the **amount of dissolved oxygen needed by bacteria** in decomposing the organic wastes present in water. It is expressed in milligrams of oxygen per litre of water.
- The **higher value of BOD indicates low DO content of water**.
- Since BOD is **limited to biodegradable materials**, it is not a reliable method of measuring water pollution.

Q. Biological Oxygen Demand (BOD) is a standard criterion for (2017)

a) Measuring oxygen levels in blood
b) Computing oxygen levels in forest ecosystems
c) Pollution assay in aquatic ecosystems
d) Assessing oxygen levels in high altitude regions

Answer: c)

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Chemical oxygen demand (COD)

- Chemical oxygen demand (COD) is a **slightly better** mode used to measure pollution load in the water.
- COD measures the **amount of oxygen** in parts per million **required to oxidise organic (biodegradable and non-biodegradable)** & **oxidizable inorganic compounds** in the water sample.

Ammonia Pollution in Sewage

- Ammonia, a **colorless gas** with a distinct odour.
- It **occurs naturally** throughout air, soil and water and in plants and animals, including humans.
- The human body makes ammonia when the body breaks down foods containing **protein into amino acids** and **ammonia**, then converting the **ammonia into urea.**
- **Ammonium hydroxide** commonly known as household ammonia is an ingredient in many everyday **household cleaning products**.
- Ammonia has been **used in municipal treatment systems** for more than 70 years **to prolong the effectiveness of disinfection chlorine** added to drinking water.
- The addition of ammonia **enhances the formation of chloramines** (may create objectionable tastes).
- It reduces the formation of chlorination by-products which may be carcinogenic.
- Ammonia is a basic building block for **ammonium nitrate fertilizer**, which releases **nitrogen**, an essential nutrient for growing plants, including farm crops and lawns.
- If the concentration of ammonia in water is **above 1 ppm it is toxic to fishes**.
- In humans, long term ingestion of water having ammonia levels of **1 ppm** or above is harmful.
- The acceptable limit of ammonia in drinking water, as per the Bureau of Indian Standards, is 0.5 ppm.

19.2.2. Industrial Wastes

- Discharge of wastewater from industries like petroleum, paper manufacturing, metal extraction and processing, chemical manufacturing, etc., that often contain toxic substances, notably, **heavy metals (defined as elements with density > 5 g/cm3** such as **mercury, cadmium, copper, lead, arsenic**) and a variety of organic compounds.

The Central Water Commission (CWC) report on Heavy Metals in Surface Water

- **Iron** emerged as the most common contaminant.
- Other major contaminants found in the samples include **lead, nickel, chromium, cadmium** and **copper**.
- Metals found in Monsoon Period (**Iron, lead, chromium,** and **copper**) exceeded tolerance limits.
- Metals found in Non-Monsoon Period include **lead, cadmium, nickel, chromium** and **copper**.
- The main sources of heavy metal pollution are mining, milling, plating and surface finishing industries.

What's the concern?

- Long-term exposure to heavy metals may result in physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy and multiple sclerosis.

19.2.3. Agricultural Sources

- Agricultural runoff contains dissolved salts such as **nitrates, phosphates, ammonia** and other nutrients, and toxic metal ions and organic compounds.
- Fertilizers contain major plant nutrients such as **nitrogen, phosphorus** and **potassium**.
- Excess fertilisers may reach the groundwater by **leaching** or may be mixed with surface water.
- Pesticides include insecticides, herbicides, etc.

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- They contain a wide range of chemicals such as **chlorinated hydrocarbons (CHCs – E.g., DDT, Endosulfan etc.)**, **organophosphates**, **metallic salts, carbonates, etc**.
- Many of the pesticides are non-degradable, and their residues have a long life. Wastes from poultry farms, piggeries and slaughterhouses etc. reach the water though runoff.

19.2.4. Thermal and Radiation Pollution

- **Power plants** – thermal and nuclear, chemical, and other industries use a lot of water for **cooling purposes**, and the used hot water is discharged into rivers, streams or oceans.
- Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature. This is **thermal pollution**.
- **Increase in water temperature decreases dissolved oxygen** in the water.
- Unlike terrestrial organisms, **aquatic organisms** are adapted to a **uniform steady temperature** of the environment. A sudden rise in temperature kills fishes and other aquatic animals.
- One of the best methods of reducing thermal pollution is to store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body.
- Nuclear accidents near water bodies or during natural calamities like tsunami and earthquakes pose the risk of **radiation leakage (radiation exposure)** into water bodies. E.g.,**Fukushima Daiichi nuclear disaster**.
- Radiation exposure causes **mutations in the DNA** of marine organisms. If those mutations are not repaired, the cell may turn cancerous.
- **Radioactive iodine** tends to be absorbed by the thyroid gland and can cause **thyroid cancer**.

19.2.5. Invasive species

- **Water hyacinth** (also called **Terror of Bengal**) are the world's most problematic aquatic weed.

- They grow abundantly in **eutrophic water bodies** and lead to an imbalance in the ecosystem.
- They cause havoc by their excessive growth leading to stagnation of polluted water.

19.2.6. Ground Water Pollution

Underground Water Pollution

- In India at many places, the groundwater is threatened with contamination due to seepage from industrial and municipal wastes and effluents, sewage channels and agricultural runoff.
- Pollutants like **fluorides, uranium, heavy metals**and **nutrients like nitrates** and **phosphates** are common in many parts of India.

Contaminated Drinking Water

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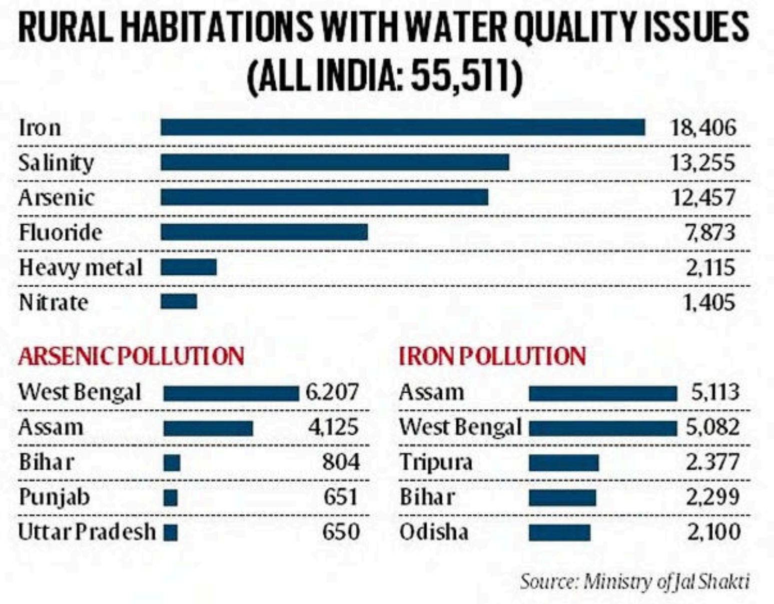
- Among rural habitations in Indian states, many face quality issues with drinking water.
- This year, 3.22 per cent of rural habitations across all states and UTs were consuming drinking water with quality issues, according to data tabled by the Ministry of Jal Shakti in Parliament.
- **Iron** is the most common contaminant, followed by **salinity, arsenic, fluoride** and **heavy metal**.
- Rajasthan has the highest number of rural habitations affected by (salinity) contamination overall.
- In terms of **arsenic and iron pollution, West Bengal and Assam** are the worst affected.
- States and UTs that are not affected by any of these contaminants include Andaman & Nicobar Islands, Goa, Gujarat, Himachal Pradesh, Ladakh, Manipur, Mizoram, Nagaland, Puducherry, Sikkim and Tamil Nadu.



Nitrates

- **Excess nitrate** in drinking water reacts with **haemoglobin** to form non-functional **methaemoglobin** and **impairs oxygen transport**. This condition is called **methemoglobinemia** or **blue baby syndrome**.
  - ⇨ ***Methaemoglobin is a form of the oxygen-carrying metalloprotein haemoglobin. Methaemoglobin cannot bind oxygen, unlike oxyhaemoglobin.***
- High level of nitrates may form carcinogens and can **accelerate eutrophication** in surface waters.

Trace metals

- Trace metals in water include **lead, mercury, cadmium, copper, chromium** and **nickel**.
- These metals can be toxic and carcinogenic.

Arsenic

- Seepage of industrial and **mine discharges, fly ash ponds of thermal power plants** can lead to arsenic in groundwater.
- In India and Bangladesh (Ganges Delta), millions of people are exposed to groundwater contaminated with high levels of arsenic, a highly toxic and dangerous pollutant.
- Chronic exposure to arsenic causes **black foot disease**— a peripheral vascular disease (PVD), in which the **blood vessels in the lower limbs are severely damaged**, resulting eventually in progressive gangrene.
- Chronic exposure to arsenic also causes diarrhoea and also lung and skin cancer.

Arsenic Affected Habitations

- The country had 1,800 arsenic-affected habitations in 2015. This increased to 4,421

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- Most of the arsenic-affected habitations lie in the **Ganga and Brahmaputra alluvial plains**—**Assam, Bihar, West Bengal, Punjab, and Uttar Pradesh (UP).**
- **Karnataka, which had nine habitations in 2015, had none in 2020.**
- Habitations are the group of households at a community level in a village.
- These are the smallest level of settlements that can have between 10-100 households.

Arsenic Poisoning

- Arsenic poisoning, or arsenicosis, occurs after the ingestion or inhalation of high levels of arsenic.
- Arsenic is a type of **carcinogen** that's gray, silver, or white in color.
- Arsenic is extremely poisonous to humans.
- Arsenic **doesn't have a taste or odor**.
- While arsenic is **naturally occurring**, it also **comes in inorganic (or "man-made") formulas**.
- These are used in **agriculture, mining, and manufacturing**.
- Arsenic poisoning tends to occur most often in **areas of industrialization**.
- Countries that have high levels of arsenic-containing groundwater include the **US, India, China,& Mexico.**

Fluoride

- Excess fluoride in drinking water causes **neuromuscular disorders, gastrointestinal problems, teeth deformity, hardening of bones** and **stiff** and **painful joints(skeletal fluorosis)**.
- Pain in bones and joint and outward bending of legs from the knees is called **Knock-Knee syndrome**.
- Fluorosis is a common problem in several states of the country due to the intake of high fluoride content water.

Uranium Contamination

- There is prevalence of **Uranium concentration above 30 micro-gram per litre (WHO provisional guidelines)**in some of the localized pockets in the country.
- In Rajasthan and other northwestern regions, uranium occurs mostly in **alluvial aquifers**; while in southern regions such as Telangana, crystalline rocks such as granite seem to be the source.
- When groundwater is over-extracted from such soils, the uranium is exposed to air, triggering its release.
- A report brought out by Central Ground Water Board states that most of the northwestern and peninsular states in India have localised occurrence of Uranium concentration.
- The AP government has ordered an inquiry into complaints about groundwater pollution caused by the uranium mining and processing project of the Uranium Corporation of India Limited (UCIL) in Kadapa district.

The impact of Uranium on health

- Uranium is weakly radioactive with a long physical half-life (~4.5 billion years for uranium-238).
- The biological half-life (time taken by human body to eliminate half the amount) is about 15 days.
- Elevated uranium level in drinking water may be associated with **kidney toxicity**.
- High rates of **chronic kidney disease (CKD)** in Srikakulam district in Andhra Pradesh is thought to be due to groundwater uranium exposure.

Guidelines in India

- The Indian Standard IS 10500: 2012 for Drinking Water specification has specified the maximum acceptable limits for radioactive residues as alpha and beta emitters, values in excess of which render the water not suitable.
- These requirements take into account all radioactive elements, including uranium.
- No individual radioactive elements have been specifically identified.

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- Further, Bureau of Indian Standard (BIS) is working to incorporate maximum permissible limit of Uranium as **0.03 mg/l (as per WHO provisional guidelines)** in all drinking water standards.

19.2.7. Freshwater Salinization Syndrome (FSS)

- **Context:** According to a recent study fresh water is turning saltier & poisoning drinking water.
- The study showed that **1/3rd**of the **streams & rivers in world got saltier over the past 25 years**.
- The study noted the risks of exposure to multiple heavy metals in drinking waterin developing countries.
- More than **57% of India's groundwater** was contaminated with**nitrate, fluoride & arsenic**.
- Saline water incursion forced many farmers to shift to cities for work in Tamil Nadu's Thoothukudi.
- Surface waters are also at risk from FSS from **oil & gas extraction**& other forms of **resource extraction**.

Relevance of the findings

- Approximately 70% of the Earth is covered by water; only about **2.5% of that is fresh water**.
- Undermining FCC problem may entail that freshwater would not have the same desired chemical; biological & physical properties & provide the same **ecosystem services** as in previous decades.

What is Freshwater Salinization Syndrome (FSS)?

- It is the process of **salty runoff contaminating freshwater ecosystems**.
- Salts naturally occur in fresh waters, typically caused by rock weathering &naturally saline groundwater.
- However, **anthropogenic activities** are further increasing concentrations of salts in fresh waters.

Causes

- **Road salts for de-icing (applying salt on snowy & icy roads has a lower freezing temperature than the surrounding ice)**.
- Human-accelerated weathering of infrastructure, rocks & soils.
- **Sea-level rise & saltwater intrusion.**
- Evaporative concentration of salt ions from hydrologic modifications & climate
- Disturbance of vegetation & local groundwater hydrology.

Effects

- The global contamination of fresh water reduces biodiversity & threatens human health.
- Toxicity to aquatic life.
- **Corrosion/degradation of built infrastructure**.

Solutions

- At present freshwater Salinization is poorly regulated & largely ignored in freshwater management. There is a need for uniform & comprehensive law.
- **Source control** is the best preventive strategy.
- Alternate **de-icers & adaptive road salt application** should be preferred.
- Remediation may occur through the creation of **a national standardized data base** where local governmentscan report the quantity & concentration of the road salts that are released for de-icing purposes.
- Need to identify thresholds that characterize effects of **ion-specific salt pollution** limits appropriate to protect human health & wellbeing, ecosystem functions & services.

Mains Practice: *"Elevated salt levels in fresh water reduce biodiversity & threaten human health". In the light of the above statement discuss increasing salinity as one of the most important environmental issues of the 21st century*. ***(150 words)***

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Q. Which of the following can be found as pollutants in the drinking water in some parts of India?

1) Arsenic
2) Sorbitol
3) Fluoride
4) Formaldehyde
5) Uranium

Select the correct answer using the codes given below.

a) 1 and 3 only
b) 2, 4 and 5 only
c) 1, 3 and 5 only
d) 1, 2, 3, 4 and 5

Explanation:

- The easiest option is 3) Fluoride. So, (b) can be eliminated.
- The next easiest option is **Arsenic (Heavy metal)**. Damn!
- The nest easiest option is Uranium. Many columns are written on uranium mining and its ill-effects. So, (a) also can be eliminated. (a) and (b) eliminated. (c) and (d) remains.
- The knowledge of either "Sorbitol" or "Formaldehyde" will give us the answer.
- We are more familiar of **formaldehyde (a carcinogen)**since it is a **volatile organic compound (VOC), an air pollutant**.
- It is a pungent-smelling colourless gas that polymerises spontaneously into paraformaldehyde, hence it is **stored as an aqueous solution**.
- It is used as a preservative to **preserve human organs**.
- It also finds some application in textile, resigns and wood industry.
- **Sorbitol (glucitol)** is a **sugar alcohol** with a sweet taste which the human body metabolises slowly.

Answer: c) 1, 3 and 5 only

19.3. Marine Pollution

- Marine pollution refers to the emptying of chemicals into the ocean and its harmful effects.
- The potentially toxic chemicals stick to tiny particles, and these are taken up by plankton and benthos animals which are deposit or filter feeders concentrating upward within food chains.
- As animal feeds usually have a high fish meal or fish oil content, toxins can be found in consumed food items obtained from livestock and animal husbandry.
- To curb marine pollution and regulate the use of the world's oceans by individual States, the nations of the world have come together to form 2 major conventions & 1 organization:
  1. **Convention on the Dumping of Wastes at Sea, to be replaced by the 1996 Protocol) and**
  2. **United Nations Convention on Law of the Sea or UNCLOS.**
  3. **International Maritime Organization**

19.3.1. Oil Spills

- The most common cause of oil spill is leakage during marine transport and leakage from underground storage tanks. An oil spill could occur during offshore oil production as well.

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Recent Incidents of Oil Spills

- An oil spill accident at **East China Sea** in 2018 released more than 136,000 tonnes of volatile petroleum products.
- **Deepwater Horizon drilling accident** was the largest accidental oil spill disaster in history that took place in 2010 releasing 779 million litres of crude oil into the **Gulf of Mexico**.
- The recent MV Wakashio spill off **Mauritius** — about 1,000 tonnes of oil spilled into a sanctuary for rare wildlife after the Japanese ship struck a coral reef in, 2020.

Impact of oil spill on marine life

- **Oil being lighter than water** covers the water surface as a thin film **cutting off oxygen** to floating plants and other producers.
- Within hours of an oil spill, the fishes, shellfish, plankton die due to suffocation and metabolic disorders.
- Birds and sea mammals that consume dead fishes and plankton die due to poisoning.

19.3.2. Marine plastic pollution

- Marine plastic pollution is said to cause ~$13 billion in economic damage to marine ecosystems each year.
- It is estimated to outweigh fish by 2050.
- Plastic has been documented even in the deepest part of the ocean (Challenger Deep in Marana Trench).
- Exposure to chemicals leaching from plastic pollution interfered with the growth, photosynthesis and oxygen production of **Prochlorococcus**, the **ocean's most abundant photosynthetic cyanobacteria**.
- The most visible and disturbing impacts of marine plastics are the ingestion, suffocation and entanglement of hundreds of marine species.
- Marine wildlife such as seabirds, whales, fishes and turtles, mistake plastic waste for prey, and most die of starvation as their stomachs are filled with plastic debris.
- **Invisible plastic** has been identified in tap water, salt and are present in all samples collected in the world's oceans, including the Arctic.
- Several chemicals used in the production of plastic materials are known to be carcinogenic.They interfere with the body's **endocrine system**, causing developmental, reproductive, neurological, and immune disorders in both humans and wildlife.

19.3.3. Convention on Dumping of Wastes at Sea

- An inter-governmental conference on the **Convention on the Dumping of Wastes at Sea** met in London in November 1972 to adopt this instrument, the **London Convention**.
- The Convention has a global character and is aimed at international control and putting an end to marine pollution.

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- The definition of dumping under the Convention relates to deliberate disposal at sea of wastes or other materials from vessels, aircraft, platforms and other man-made structures.
- 'Dumping' here **does not cover** wastes derived from the **exploration and exploitation of sea-bed mineral resources**.
- The 1978 amendment dealt with the **incineration of wastes at sea**.
- The 1993 amendments **banned dumping of low-level radioactive wastes** into the seas.
- They **phased out the dumping of industrial wastes** by 1995 and called for an end to incineration of industrial wastes at sea.
- It is to be noted that dumping of low-level radioactive wastes and industrial wastes as well as incineration of wastes were earlier permitted by the Convention.
- The changing approach, keeping in view the need of the times, led to the adoption of the 1996 Protocol on November 7, 1996.

1996 Protocol

- The Protocol, which became effective in 2006, replaces the 1972 Convention.
- The 1996 Protocol is **much more restrictive** as compared to the 1972 Convention that allowed dumping provided certain conditions were satisfied.
- 1996 Protocol calls for appropriate preventive measures to be taken when wastes thrown into the sea are likely to cause harm "even when there is no conclusive evidence to prove a cause relation between inputs and their effects."
- The Protocol states that "**the polluter should, in principle, bear the cost of pollution**".
- The Contracting Parties must ensure that the Protocol does not simply result in pollution being transferred from one part of the environment to another.
- The Protocol prohibits the Contracting Parties from dumping "wastes or any other matter with the exception of those listed in Annex 1".
- Annex 1 includes dredged material; sewage sludge; fish waste from industrial fish processing operations etc. for which the concern is mainly physical impact.
- The Protocol **prohibits incineration of wastes at sea** (permitted by the 1972 convention but prohibited under the 1993 amendments).
- The Protocol states that "Contracting Parties **shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea**".
- The **International Maritime Organization (IMO)** is responsible for Secretariat duties with respect to the Protocol.

2006 Amendments to the Protocol

- Adopted in 2006, the amendments were enforced in 2007.
- The amendments have created a basis in international environment law to **regulate carbon capture and storage in sub-sealed geological formation**.
- It is part of the measures being considered to address **climate change** and **ocean acidification** like developing low carbon energy forms especially for sources of enormous CO_2 emissions.
- The amendments **allow storage of carbon dioxide (CO_2)** under the seabed but **regulate the sequestration of CO_2 streams from CO_2 capture processes in sub-seabed geological formations**.

19.3.4. The United Nations Convention on Law of the Sea

- UNCLOS establishes general obligations for safeguarding the marine environment and protecting freedom of scientific research on the high seas.

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- It also creates a legal regime for controlling resource exploitation in **deep-seabed areas** beyond national jurisdiction, through an **International Seabed Authority**(167 Member States + EU, **India is a member)**.
- UNCLOS can hold states liable for damage caused by violation of their international obligations to combat pollution of the seas.
- The convention has created 3 new institutions:
    - International Tribunal for Law of Sea
    - International Sea Bed Authority
    - Commission on the limits of continental shelf
- The convention gives a clear definition on Internal Waters, Territorial Waters, Contiguous Zone, Exclusive Economic Zone & Continental Shelf.
- It provides right to landlocked states for access to and from sea, without taxations of traffic through transit states.

International Seabed Authority

- It organizes, regulates & controls all mineral related activities in the international seabed area **beyond the limits of national jurisdiction**.
- With a 15-year contract period ISA has allowed **8 players** to exploit seabed for polymetallic nodules (India is one among the 8 players that has rights to explore **Central Indian Ocean Basin**).

19.3.5. International Maritime Organization

- It is the **global standard setting authority** for the safety, security & environmental performance of international shipping.
- **Objective:** Improvement of maritime safety & prevention of marine pollution.
- IMO measures cover **accidental & operational oil pollution.**
- Maritime Environment Protection Committee is responsible for coordinating the organisations activities in prevention & control of marine pollution.
- **HQ: United Kingdom (Only UN Special Agency to have it headquarter in UK)**

Ballast Water Management Convention (2004)

- **The IMO convention** aims to **prevent spread of harmful aquatic organisms** from one region to another.
- Ballast water is **water carried in ship's ballast tanks** to improve its stability & balance**.**
- It is taken up or discharged when cargo is unloaded or loaded.
- Without special precautions, this practice causes a **massive spread of marine organisms** from their native habitats to areas where they do not naturally occur.
- Ballast water is therefore widely regarded as the most important vector for the spread of **potentially invasive alien species**.

Bunker Convention (2001)

- It ensures that adequate & effective **compensation** is available to persons who suffer **damage caused by oil spills.**
- It applies to damage caused on the territory, including **territorial sea, exclusive economic zone** of state parties.
- It is modelled on the **International Convention on Civil Liability for Oil Pollution Damage, 1969.**

Note: India has ratified both the conventions of IMO

Regional Oil Spill Contingency Plan

- It was jointly launched by **SACEP** & **International Maritime Organization (IMO).**

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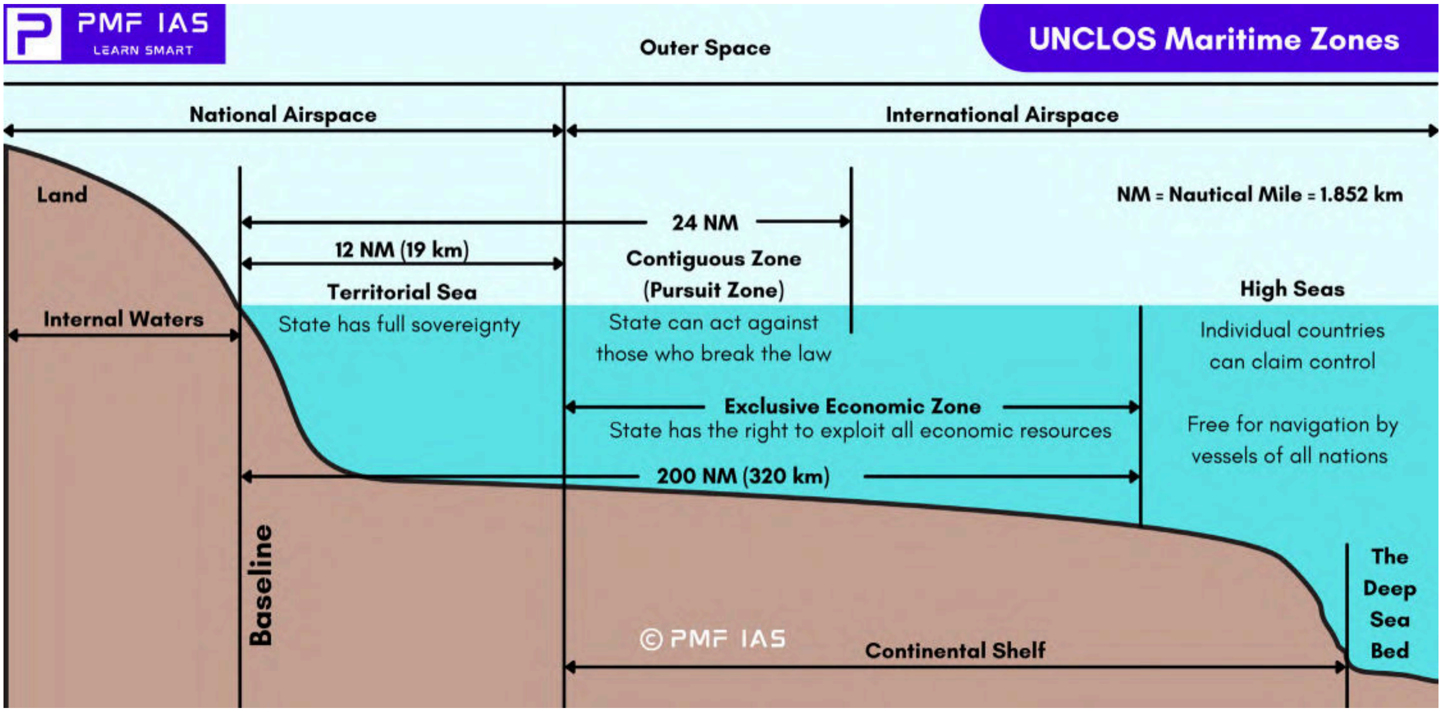
- To facilitate international cooperation and mutual assistance in preparing and responding to a major oil pollution incident in the seas around **Bangladesh, India, Maldives, Pakistan and Sri Lanka**.



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20. Water Pollution Effects and Control Measures

20.1. Effects of Water Pollution

20.1.1. Effects of Water Pollution on Human Health

- Domestic and hospital sewage contain many undesirable pathogenic microorganisms, and its disposal into water without proper treatment may cause an outbreak of serious diseases, such as typhoid, cholera, etc.
- Metals such as **lead, zinc, arsenic, copper, mercury** & **cadmium** in industrial wastewaters adversely affect humans and other animals.
- Consumption of such **arsenic polluted water** leads to accumulation of arsenic in the body parts like blood, nails and hairs causing skin lesions, rough skin, dry and thickening of the skin and ultimately **skin cancer**.
- Mercury compounds in wastewater are converted by bacterial action into extremely toxic **methyl mercury**, which can cause numbness of limbs, lips and tongue, deafness, blurring of vision and mental derangement.
- Mercury in water causes **Minamata (a neurological syndrome)** in humans.
- Lead causes **lead poisoning** (interferes with a variety of body processes and is toxic).
- The compounds of lead cause **anaemia**, headache, loss of muscle power and bluish line around the gum.
- Water contaminated with **cadmium** can cause **itaiitai** disease also called **ouch-ouch disease** (a painful **disease of bones and joints**) and cancer of lungs and liver.

20.1.2. Effects of Water Pollution on the Environment

- Micro-organisms involved in **biodegradation of organic matter** in sewage waste **consume a lot of oxygen** and **make water oxygen deficient** killing fish and other aquatic creatures.
- Presence of large amounts of nutrients in water results in **algalbloom** (**excessive growth of planktonic algae**.This leads to **ageing of lakes**).
- A few toxic substances, often present in industrial wastewaters, can undergo **biological magnification (Biomagnification) in the aquatic food chain**.
- This phenomenon is well-known for **mercury** and **DDT**.
- High concentrations of **DDT** disturb **calcium metabolism in birds**, which causes **thinning of eggshell** and their premature breaking, eventually causing a **decline in bird populations**.

20.1.3. Effects of Water Pollution on Aquatic Ecosystem

- Hot waters discharged from industries, when added to water bodies, lowers its DO content. **Polluted water reduces Dissolved Oxygen (DO)** content, thereby, eliminates sensitive organisms like plankton, molluscs, and fish etc.
- However, a few tolerant species like **Tubifex (annelid worm)** and some insect larvae may survive in highly polluted water with low DO content. Such species are recognized as **indicator species** for polluted water.
- **Biocides, polychlorinated biphenyls (PCBs)** and **heavy metals** eliminate sensitive aquatic organisms.

Ocean warming, overfishing increase methylmercury toxin in fish

- There is a decrease in seawater concentration of **methylmercury** since the late 1990s.
- However, amount of methylmercury in fish which are higher in the food chain have been found to increase.
- The increase is due to two reasons: — **ocean warming** and dietary shifts due to **overfishing** by humans.
- Due to overfishing, fish higher in the food chain relied more on larger fishes, which have higher concentrations of the toxin than other prey fish.

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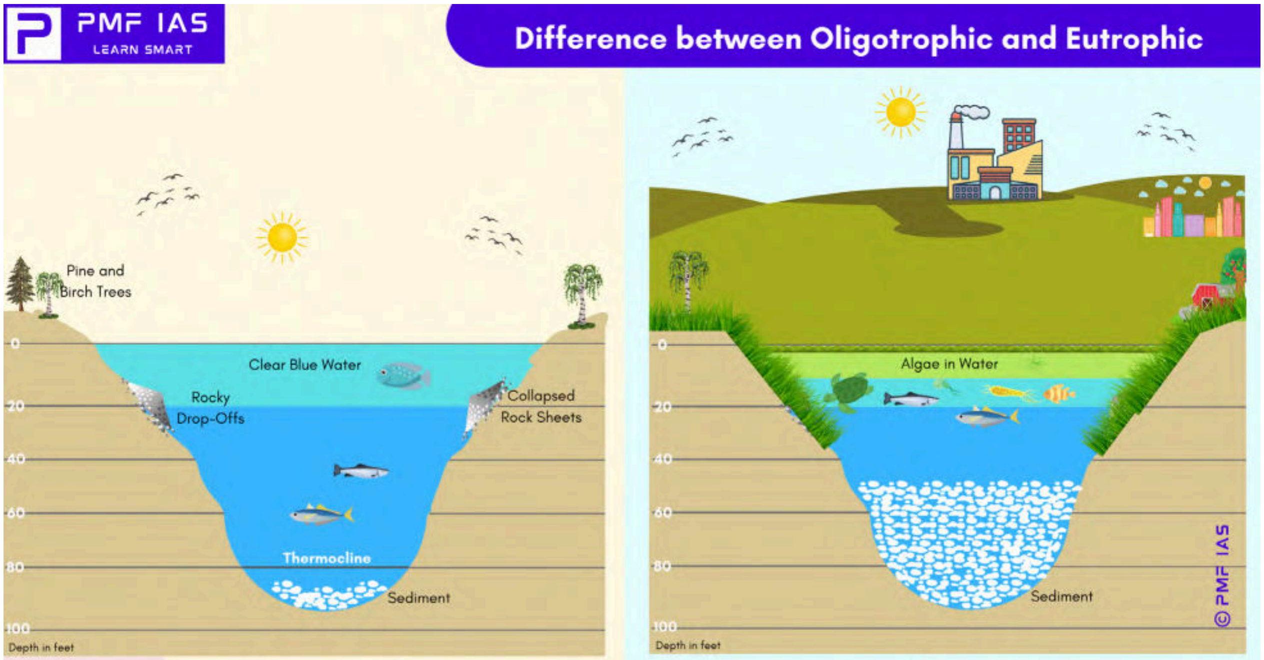
- Fish metabolism is temperature dependent. So, **as ocean temperature increases, fish experience higher metabolism and more energy obtained from food is spent on maintenance rather than growth**.
- This leads to more methylmercury getting concentrated in predatory fish (fish higher in the food chain).
- Human exposure to the toxin through fish consumption is bound to increase as a result of climate change.

Methylmercury

- Methylmercury is a very poisonous form of mercury.
- It is used in **fluorescent lights, batteries, and polyvinyl chloride**.
- In the environment, methylmercury forms when bacteria react with mercury in water, soil, or plants.
- In Japan, mass mercury poisoning (**Minamata disease**) was observed in the 1960s, caused by eating fish from Minamata Bay which was contaminated with methylmercury.
- Methylmercury poisoning leads to brain and nervous system damage.
- The developing foetus is highly vulnerable to mercury exposure.

20.1.4. Eutrophication – Ageing of Lakes



Characteristics	Oligotrophic	Eutrophic
Definition	It is a lake that has few nutrients present and also a low primary productivity	It is a lake that has abundant nutrients present and also a high primary productivity
Water Parameters	Low Turbidity, High Oxygenation at depth, and clear water	High Turbidity, Low Oxygenation at depth, and water often is brown or with a greenish tint.
Primary Producers	Low Concentrations	High Concentrations
Primary Productivity	Is less than 100 mg of carbon/m^2 a day.	Is more than 100 mg of carbon/m^2 a day.
Consumers	Many fish at Deep Levels.	Few Fish at Deep Levels.
Microbes	Reduced Biomass.	Increased Biomass.

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- Lakes receive their water from surface runoff and along with its various chemical substances and minerals.
- Over periods spanning millennia, ageing occurs as the lakes accumulate mineral and organic matter and gradually, get filled up. The **nutrient-enrichment** of the lakes promotes the growth of **algae**, aquatic plants, and various fauna.
- This process is known as **natural eutrophication**.
- Similar **nutrient enrichment of lakes at an accelerated rate** is **caused by human activities**and the consequent ageing phenomenon is known as **cultural eutrophication**.
- On the basis of their nutrient content, lakes are categorized as **Oligotrophic (very low nutrients)**, **Mesotrophic (moderate nutrients)** and **Eutrophic (highly nutrient rich)**.
- A vast majority of lakes in India are either **eutrophic or mesotrophic** because of the nutrients derived from their surroundings or organic wastes entering them.

20.1.5. Eutrophication and Algal Bloom

- **Eutrophic water body:** it is a body of **water rich in nutrients** and so supporting a dense plant population, the **decomposition** of which kills animal life by **depriving it of oxygen**.
- Eutrophication is the response to the addition of nutrients such as **nitrates** and **phosphates** naturally or artificially, fertilising the aquatic ecosystem.
- **Phytoplankton (algae and blue-green bacteria)** thrive on the excess nutrients and their population explosion covers almost entire surface layer. This condition is known as **algal bloom**.

Phytoplankton

- Phytoplankton are tiny, microscopic **autotrophs** found in the ocean.
- They are important **ecological indicators** that regulate life in ocean.
- They have chlorophyll to capture sunlight and use photosynthesis to turn it into chemical energy.
- All phytoplankton photosynthesise, but some get additional energy by consuming other organisms.
- Phytoplankton contribute to more than half of the oxygen that we breathe.
- They influence our climate by **absorbing human-induced carbon dioxide**.
- They also serve as the foundation of the aquatic food web.
- Phytoplankton include a wide variety of marine autotrophs like **diatoms, dinoflagellates, cryptomonads, green algae, blue green algae,** etc.

Chlorophyll

- Chlorophyll is **a green photosynthetic pigment** found in **plants, algae, and cyanobacteria**.
- Chlorophyll absorbs mostly in the **blue and to a lesser extent red portions** of the electromagnetic spectrum, hence its intense green colour.

Types of Chlorophyll

1. **Chlorophyll a**, found in **all higher plants, algae and cyanobacteria**.
2. **Chlorophyll b**, found in **higher plants and green algae**.
3. **Chlorophyll c**, found in **diatoms, dinoflagellates and brown algae,**
4. **Chlorophyll d**, found **only in red algae**.

Mechanism

- Phytoplankton are **photosynthetic during daytime adding oxygen to the aquatic ecosystem**.
- But **during nights, they consume far more oxygen as they respire aggressively**.

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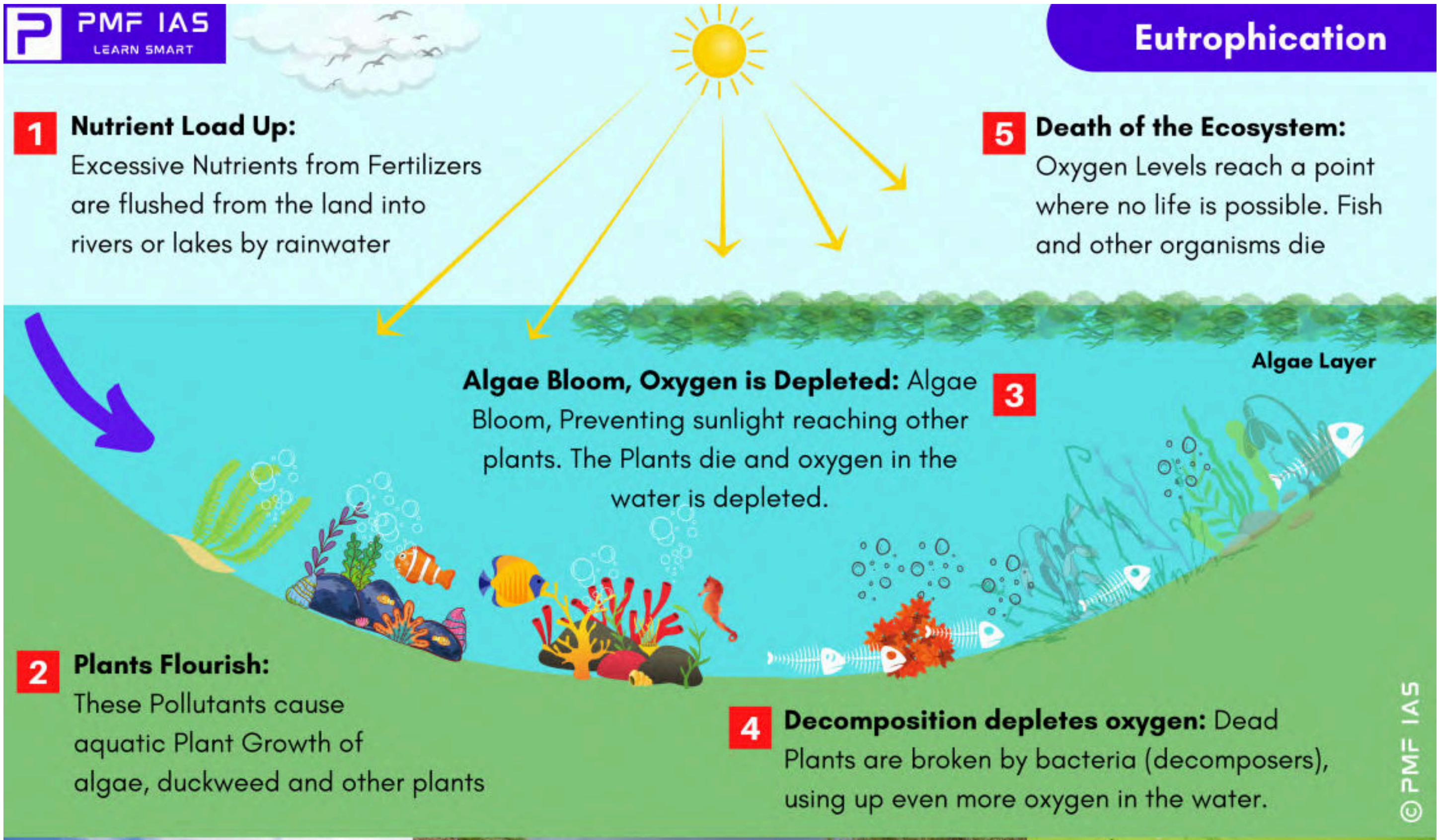
- Therefore, **algal blooms accentuate the rate of oxygen depletion** as the population of phytoplankton is exceedingly high.
- The primary consumers like small fish are killed due to **oxygen deprivation** caused by algal blooms.
- Death of primary consumers adversely affects the food chain.
- Further, more **oxygen is taken up by microorganisms during the decomposition process** of dead algae, plants, and fishes.
- The new **anaerobic conditions (absence of oxygen)** created promote the growth of bacteria such as **Clostridium botulinum** which produces toxins deadly to aquatic organisms, birds, and mammals.
- Water temperature has also been related to the occurrence of algal blooms, with **unusually warm water being conducive to blooms**.
- **Algal blooms** can be any colours, but the most common ones are **red or brown**. These blooms are commonly referred to as **red or brown tides**.

Harmful Algal Blooms



- Most algal blooms are not harmful, but some produce toxins & are known as Harmful Algal Blooms (HABs).
- Toxicity: Some algal blooms release **neuro & hepatotoxins** which can kill aquatic organism & pose a threat to humans. E.g., **Shellfish poisoning**.
- HAB events adversely affect commercial and recreational fishing, tourism, and valued habitats.

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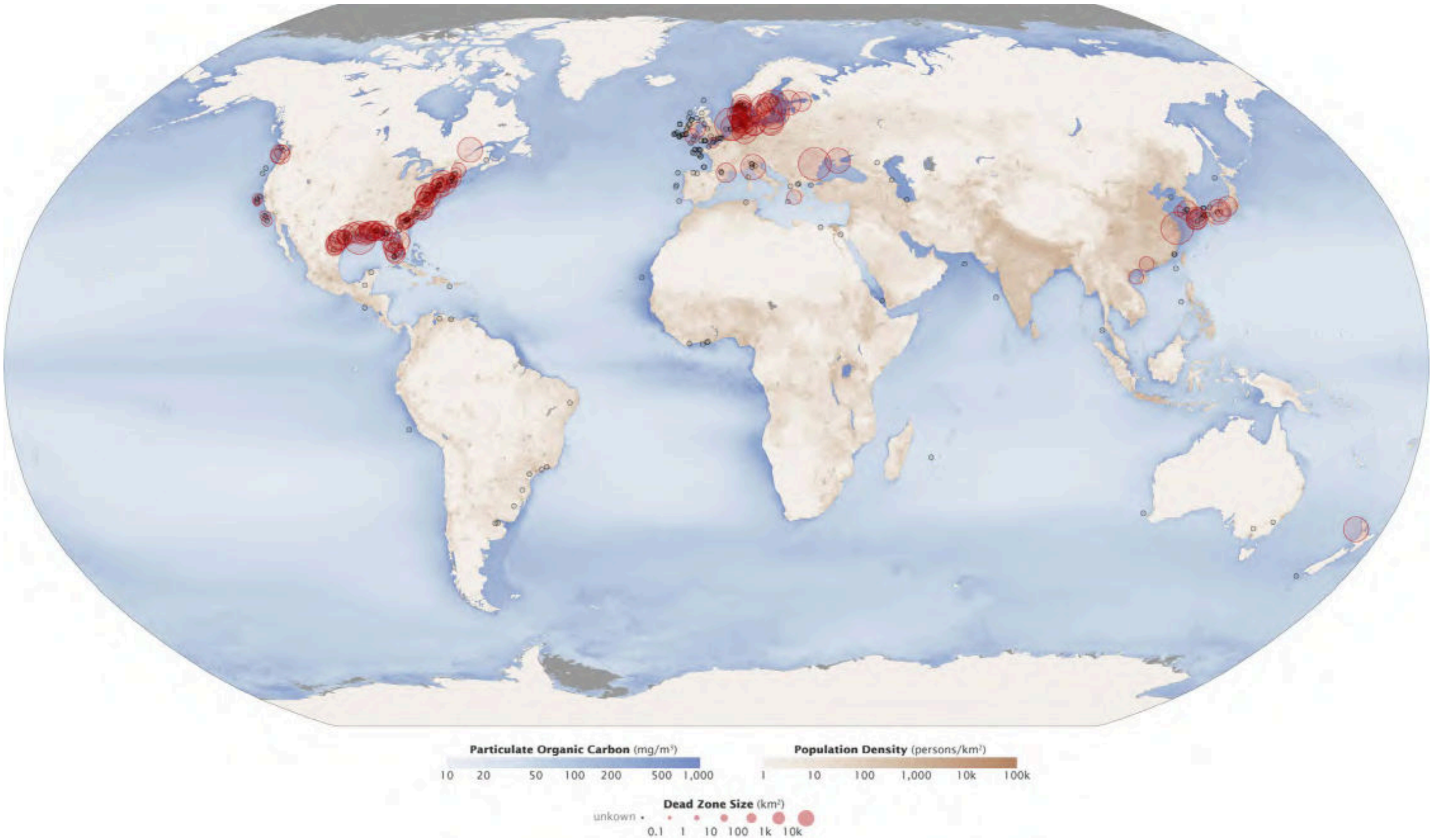
20.1.6. Effects of Eutrophication

- **Algal Blooms** restrict the penetration of sunlight resulting in the **death of aquatic plants** and hence restricts the replenishment of oxygen.



- New species invasion: Eutrophication may cause the ecosystem competitive by transforming the normal limiting nutrient to abundant level. Thiscause shifting in species composition of the ecosystem.
- **Loss of freshwater lakes:** Eutrophication eventually creates **detritus layer** in lakes and produces successively **shallower** depth of surface water.
- Eventually, the water body is reduced into marsh whose plant community is **transformed** from an aquatic environment to a recognizable **terrestrial** environment.
- **Loss of coral reefs:** Occurs due to decrease in water transparency (**increased turbidity**).
- Affects navigation due to increased turbidity; creates colour (yellow, green, red), smell; increases biomass of **inedible toxic phytoplankton**, benthic and epiphytic algae and bloom of gelatinous zooplankton.

World's oceans have less oxygen today

- According to a study by IUCN, the world's oceans have less oxygen today than they did in the 1960s.
- The fall in oxygen levels is around 2 percent from 1960 to 2010.
- The primary causes of deoxygenation are eutrophication and nitrogen deposition from the burning of fossil fuels, coupled with the widespread impacts from **ocean warming**.

Red circles show the size and location of dead zones in 2010. Black dots indicate dead zones of unknown size. Dark blue regions indicate overly fertile water that may give rise to dead zones. (NASA Earth Observatory)

- Warmer oceans cause deoxygenation both **because oxygen is less soluble in warmer water**, and through temperature driven stratification.
- Ice melt and glacial runoff results in a less salty and therefore a **less dense layer that floats on top**.
- This **stratification inhibits the upwelling of nutrients** into the upper layer of the ocean.

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- This is where most of the oceanic photosynthesis (such as by phytoplankton) occurs.
- This decrease in nutrient supply is likely to decrease rates of photosynthesis in the surface ocean.

Dead zones

- Dead zones (**biological deserts**) are increasing in the coastal delta and estuarine regions.
- **Hypoxic zones (zones deprived of oxygen)** can occur naturally (due to upwelling of nutrients).
- They can be created or enhanced by human activity to form dead zones.
- Dead zones are areas in the ocean with **very low oxygen concentration (hypoxic conditions)**.
- Dead zones emerge when **influx of chemical nutrients spur algae growth**.
- These zones usually occur 200-800 meters (in the saltwater layer) below the surface.
- Dead zones are **detrimental to animal life**. Most of the animal life either dies or migrates from the zone.
- One of the largest dead zones forms in the **Gulf of Mexico** every spring (farmers fertilize their crops and rain washes fertilizer off the land and into streams and rivers).
- There's a dead zone in Gulf of Oman and it's growing.
- Mechanism of formation of dead zones: **1) Eutrophication, 2) Algal Bloom and 3) Hypoxic condition**

Q. What are the consequences of spreading of 'Dead Zones' on marine ecosystems? (2018)

20.1.7. Blue Tide

- **Bioluminescence or light-emitting tide** made an appearance along the coastline of Mumbai.
- The **blue tide** phenomenon appears when **luminescent marine life makes the sea appear deep blue.**
- The spectacle occurs when **phytoplankton (microscopic marine plants), commonly known as dinoflagellates, produce light through chemical reactions in proteins.**
- Waves disturb these unicellular microorganisms and make them release blue light.
- Factors such as the **wind pattern and the temperature of the ocean** also determine their occurrence.

What is Bioluminescence?

- Bioluminescence is the property of a living organism to produce and emit light.
- **Animals, plants, fungi, and bacteria show bioluminescence**.
- It is found in many marine organisms such as bacteria, algae, jellyfish, crustaceans, sea stars, fish, sharks, etc.
- Luminescence is **generally higher in deep-living and planktonic organisms** than in shallow species.

Why do they glow?

- It is an **antipredator response**.
- Bioluminescence is assumed to startle predators, causing them to hesitate, in a form of predator intimidation.
- Bioluminescence helps these organisms gather and make colonies.

Is the Blue Tide harmful?

- While smaller blooms may be harmless, **slow-moving larger blooms impact deep-sea fishing.**
- According to experts, the **phenomenon is an indicator of climate change.**
- It is an **indicator of degraded water quality**.
- The phytoplankton shows up where seawater has **low dissolved oxygen and a high presence of Nitrogen**.
- Bioluminescence could have been caused by **heavy rain, fertilizers run off, discharge of sewage**, etc.

20.2. Water Pollution Control Measures

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- The Government of India has passed the **Water (Prevention and Control of Pollution) Act, 1974** to safeguard our water resources.
- An ambitious plan to save the river called the **Ganga Action Plan** was launched in 1985.
- In India, the **Central Pollution Control Board (CPCB)**, an apex body in the field of water quality management, has developed a concept of "designated best use".
- Accordingly, the water body is designated as A, B, C, D, E on the basis of
    - ✓ **pH,**
    - ✓ **dissolved oxygen, mg/l**
    - ✓ **BOD, (200C) mg/l**
    - ✓ **total coliform (MPN/100ml)**
    - ✓ **free ammonia mg/l,**
    - ✓ **electrical conductivity etc.**
- The CPCB, in collaboration with the concerned State Pollution Control Boards, has classified all the water bodies in the country according to their "designated best uses".
- This classification helps the water quality managers and planners to set water quality targets and identify needs and priority for water quality restoration programmes.
- The **Ganga Action Plan** and subsequently the **National River Action Plan** are results of such exercise.
- **Riparian buffers:** A riparian buffer is a vegetated area (a "buffer strip") near a stream, usually forested, which helps shade and partially protect a stream from the impact of adjacent land uses.
- Treatment of sewage water and the industrial effluents before releasing it into water bodies. Hot water should be cooled before release from the power plants.
- Excessive use of fertilisers and pesticides should be avoided. Organic farming and efficient use of animal residues as fertilisers can replace chemical fertilizers.
- **Water hyacinth** (an **aquatic weed, invasive species**) can purify water by taking some toxic materials and a number of heavy metals from water.
- Oil spills in water can be cleaned with the help of **bregoli** — a by-product of paper industry resembling sawdust, oil zapper, microorganisms.
- Planting **eucalyptus** trees all along sewage ponds is suggested. These trees absorb all surplus wastewater rapidly and release pure water vapour into the atmosphere.

20.2.1. Bioremediation

- Bioremediation is the **use of microorganisms (bacteria and fungi) to degrade the environmental contaminants** into less toxic forms.
- Microorganisms can be specifically designed for bioremediation using **genetic engineering techniques**.

In situ bioremediation

- In situ — involves treatment of the contaminated material at the site.
- **Bioventing:** supply of nutrients through wells to contaminated soil to stimulate the growth of bacteria.
- **Biosparging:** Injection of air under pressure below the water table to **increase groundwater oxygen concentrations** and enhance the rate of biological degradation of contaminants by bacteria.
- **Bioaugmentation:** Microorganisms are imported to a contaminated site to enhance the degradation process.
- Using bioremediation techniques, TERI has developed a mixture of bacteria called '**Oilzapper** and **Oilivorous-S**' which degrades the pollutants of oil-contaminated sites, leaving behind no harmful residues.

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Q. Recently, 'oilzapper' was in the news. What is it?

a) It is an eco-friendly technology for the remediation of oil sludge and oil spills.
b) It is the latest technology developed for under-sea oil exploration.
c) It is a genetically engineered high biofuel yielding maize variety.
d) It is the latest technology to control the accidentally caused flames from oil wells.

Answer: a) Current Affairs based question. Keep track of the latest developments.

Ex situ bioremediation

- Ex situ — involves the removal of the contaminated material to be treated elsewhere.
- **Landfarming:** contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded. The goal is to stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation of contaminants.
- **Bioreactors:** it involves the processing of contaminated solid material (soil, sediment, sludge) or water through an engineered containment system.
- **Composting:** Composting is nature's process of recycling decomposed organic materials into a rich soil known as compost.

Advantages of bioremediation

- Destroys a wide variety of contaminants.
- The destruction of target pollutants is possible.
- Less expensive.
- Environment-friendly.

Disadvantages of bioremediation

- Bioremediation is limited to biodegradable compounds. Not all compounds are susceptible to rapid and complete degradation.
- Bioremediation often takes a longer time than other treatment processes.

Bioremediation of Arsenic

- Using **arsenic (arsenate & arsenite are the toxic forms)** contaminated water for agricultural purposes can lead to increased concentration of arsenic in fruits and grains, proving toxic to humans.
- Arsenic can be removed from contaminated soil with the help of **Bacillus flexus** and **Acinetobacter junii**.
- B. flexus exhibited resistance to arsenate and A. junii to arsenite.
- Both the bacteria have a special gene, which aids in **arsenic detoxification**.

Q. In the context of solving pollution problems, what is/are the advantage/advantages of bioremediation technique?

1) It is a technique for cleaning up pollution by enhancing the same biodegradation process that occurs in nature.
2) Any contaminant with heavy metals such as cadmium and lead can be readily and completely treated by bioremediation using microorganisms.
3) Genetic engineering can be used to create microorganisms specifically designed for bioremediation.

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only

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c) 1 and 3 only
d) 1, 2 and 3

Bioremediation is limited to biodegradable compounds. Answer: c) 1 and 3 only

Phytoremediation

- Phytoremediation is the use of **plants** to remove contaminants from soil and water.
- Natural phytoremediation is carried out by mangroves, estuarine vegetation and other wetland vegetation.
- **Phytoextraction/phytoaccumulation**: plants accumulate contaminants into the roots and aboveground shoots or leaves.

20.2.2. Sewage Water Treatment for Domestic Use

- Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, and minerals such as iron and manganese. The processes involved in removing the contaminants include physical processes such as settling and filtration, chemical processes such as disinfection and coagulation and biological processes such as slow sand filtration.

Coagulation / Flocculation

- **Aluminium sulphate (alum)** is the most common **coagulant** used for water purification.
- Other chemicals, such as **ferric sulphate or sodium aluminate**, may also be used.
- During coagulation, **liquid aluminium sulfate (alum)**is added to untreated water.
- This causes the tiny particles of dirt in the water to stick together or coagulate.
- Next, groups of dirt particles stick together to form larger particles called flocs.
- Flocs are easier to remove by settling or filtration.

Sedimentation

- As the water and the floc particles progress through the treatment process, they move into sedimentation basins where the water moves slowly, causing the heavy floc particles to settle to the bottom.
- Floc which collects on the bottom of the basin is called **sludge** and is piped to drying lagoons.
- In direct filtration, the sedimentation step is not included, and the floc is removed by filtration only.

Filtration

- Water flows through a filter designed to remove particles in the water.
- The filters are made of layers of sand and gravel, and in some cases, crushed **anthracite (coal)**.
- Filtration collects the suspended impurities in water and enhances the effectiveness of disinfection.

Disinfection

- Water is disinfected before it enters the distribution system to ensure that any disease-causing bacteria, viruses, and parasites are destroyed.
- **Chlorine**is used because it is a very effective disinfectant, and residual concentrations can be maintained to guard against possible biological contamination in the water distribution system.
- The addition of chlorine or chlorine compounds to drinking water is called **chlorination**.
- Chlorine can combine with certain naturally occurring organic compounds in water to produce **chloroform** and other potentially harmful by-products.
- The risk of this is very smallwhen chlorine is applied after coagulation, sedimentation, and filtration.

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- **Ozone gas** may also be used for disinfection of drinking water. However, since ozone is unstable, it cannot be stored and must be produced on-site, making the process more expensive than chlorination.
- Ozone has the advantage of **not causing taste or odour problems**. It also leaves no residue in the disinfected water.
- The lack of an ozone residue, however, makes it difficult to monitor its continued effectiveness as water flows through the distribution system.

Fluoridation

- Water fluoridation is the treatment of community water supplies for the purpose of adjusting the concentration of the free **fluoride ion** to the optimum level sufficient **to reduce dental cariesor cavities**.
- Fluoride is generally present in natural water. Its concentration up to a certain level is not harmful. Beyond that level, the **bones start disintegrating**. This disease is called **fluorosis**.
- We have fluoride problem in many parts of our country. Bureau of Indian Standards prescribes 1.0 mg/l as desirable and 1.5 mg/l as a maximum permissible limit for drinking water.
- **Defluorination** at domestic level can be carried out by mixing water for treatment with an adequate amount of **aluminium sulphate (alum) solution, lime or sodium carbonate and bleaching powder** depending upon its alkalinity (concentration of bicarbonates and carbonates in water) and fluoride contents.

pH Correction

- **Lime** is added to the filtered water to adjust the pH and stabilise the naturally soft water **in order to minimise corrosion** in the distribution system and within customers' plumbing.

Removal of iron

- In many parts of India,this is a problem of excess iron in drinking water, especially in **North-East regions**.
- Iron causes bad taste and odour to the drinking water.
- Bureau of Indian Standards prescribes desirable limit for iron as 0.3 mg/l.
- A major part of iron is oxidised. Then the water is made to react with **oxidising media (limestone)**.
- By aeration and further oxidation, the dissolved iron is converted to **insoluble ferric hydroxide**.
- The insoluble iron can thus be easily removed through filtration.

Removal of arsenic

- Arsenic is found in groundwater in some parts of West Bengal. Arsenic is highly toxic.
- Bureau of Indian Standards prescribes desirable limit for arsenic as 0.05 mg/l.
- **Bleaching powder and alum**are used for the removal of arsenic.

20.2.3. Bio-Toilets

- Direct discharge of human waste from the existing toilet system in trains causes **corrosion of the tracks**, costing crores to replace the rail tracks.
- The bio-toilets are fitted underneath the lavatories and the human waste discharged into them is acted upon by a particular kind of **bacteria** that converts it into non-corrosive **neutral water**.
- Bio-toilets for the Indian trains were designed by **Indian Railways** in association with **DRDO**.

Terms associated with Bio-Toilets

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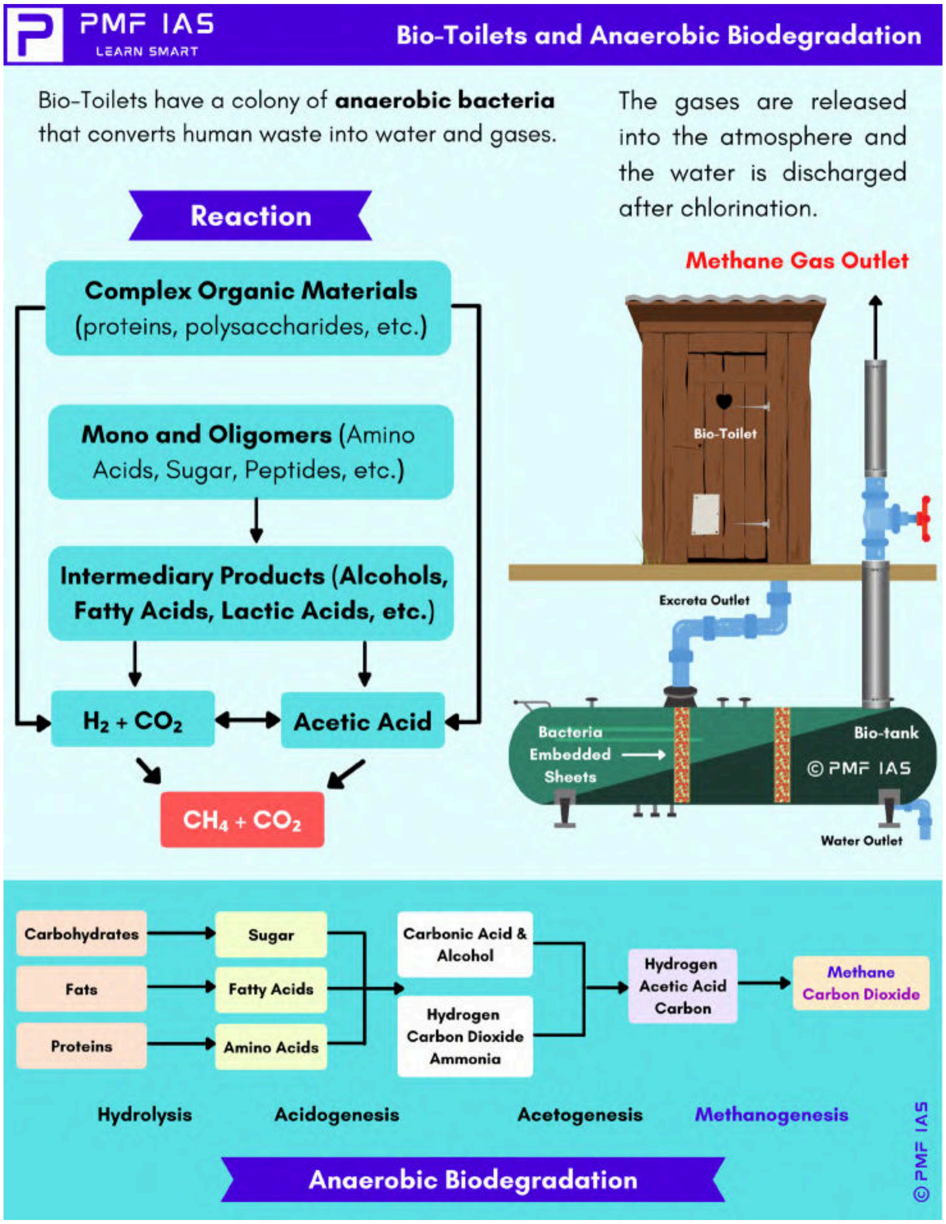

- **Bio-digesters:** shells of steel for the **anaerobic digestion** of human waste.
- **Bio-tank:** tanks made up of concrete for the **anaerobic digestion** of human waste.
- **Aerobic Bacteria:** Aerobic bacteria are those which**flourish in the presence of free dissolved oxygen** in the wastewater and consume organic matter for their food, and thereby oxidising it to stable end products.
- **Anaerobic Bacteria:** Anaerobic bacteria **flourish in the absence of dissolved oxygen** and**survive by utilizing the bounded molecular oxygen in compoundslike nitrates (NO_3), sulphates (SO_4)** etc. thereby reducing them to stable end products along with evolution of foul-smelling gases like **H_2S (hydrogen sulphide)**and **CH_4 (methane)**.
- **Facultative Bacteria:** Facultative bacteria can operate **either** as aerobically or as anaerobically.
- **Anaerobic Microbial Inoculums:** a mixture of different types of bacteria responsible for the breakdown of complex polymers into simple sugars which are further broken down into low chain fatty acids and finally into **biogas**.

Anaerobic Biodegradation System

- Anaerobic digestion is a collection of processes by which microorganisms break down biodegradable material in the **absence of oxygen**. The final waste is **Methane** and **Carbon Dioxide**.

Anaerobic Gas Lift Reactor (AGR)

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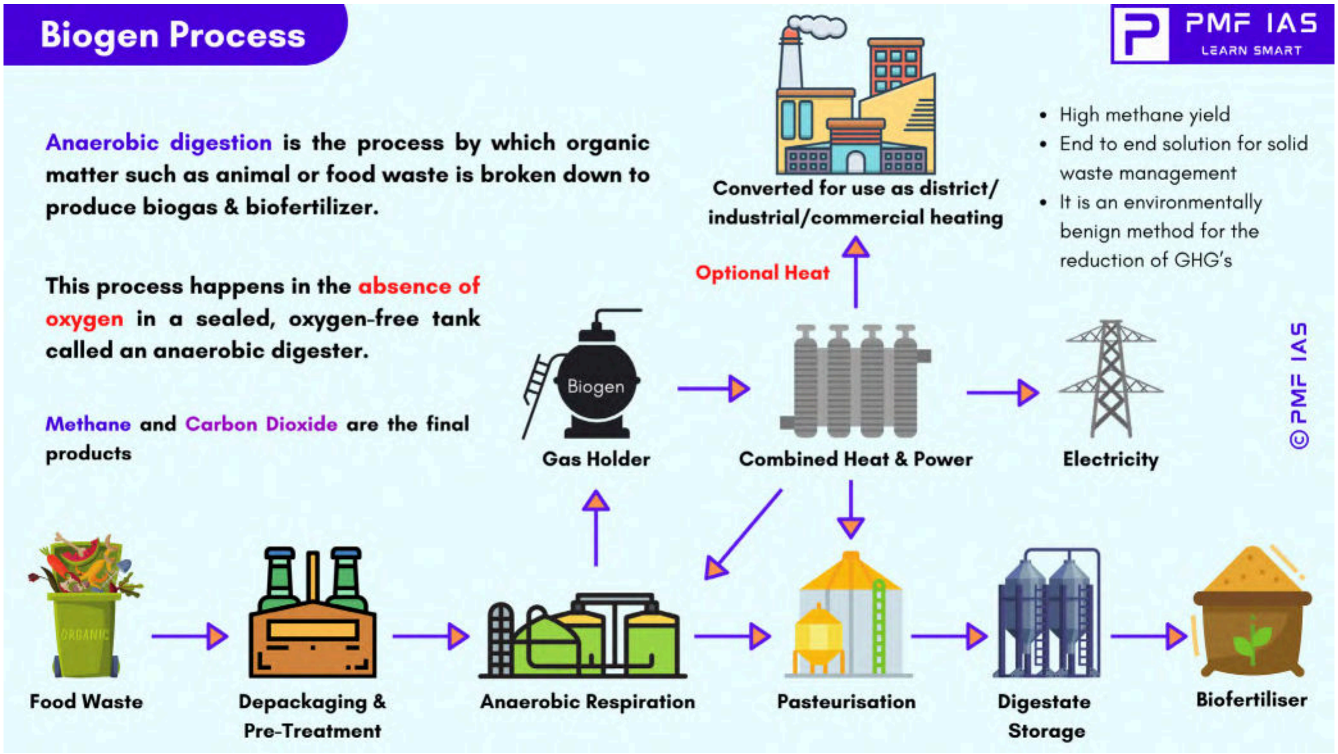
- **Context:** CSIR-Indian Institute of Chemical Technology (IICT) has designed the high rate biomethanation technology based Anaerobic Gas lift Reactor (AGR).
- The technology is meant for scientific treatment and disposal of organic waste through the generation of renewable energy in the form of **biogas & bio-manure**.

Anaerobic digester

- Anaerobic digestion is the process by which organic matter such as animal or food waste is broken down to produce **biogas & biofertilizer**.
- This process happens in the **absence of oxygen** in a sealed, oxygen-free tank called an anaerobic digester.
- Every tonne of food waste recycled by anaerobic digestion as an alternative to landfill prevents between 0.5 and 1.0 tonne of CO_2 entering the atmosphere, one of the many benefits of anaerobic digestion.



Benefits

- Incorporated with high-rate anaerobic digester (no foul smell, renewal energy is produced).
- High methane yield.
- End to end solution for solid waste management.
- It is an environmentally benign method for the reduction of GHG's also.
- Could be designed for the treatment of 500 kg to 10 tons of organic solid waste per day.

Q. With reference to bio-toilets used by the Indian Railways, consider the following statements:

1) The decomposition of human waste in the bio-toilets is initiated by a fungal inoculum.
2) Ammonia and water vapour are the only end products in this decomposition which are released into the atmosphere.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only

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c) Both 1 and 2
d) Neither 1 nor 2

Explanation:

- Decomposition of human waste in bio-toilets is carried out by **anaerobic bacteria**.
- The final waste is **CO_2 and CH_4**.

Answer: d) Neither 1 nor 2

The Disadvantages of Aerobic Biodegradation

- Forced aeration is essential which is energy intensive.
- Incomplete aeration (partial aerobic condition) leads to a foul smell.
- **Cannot tolerate detergents**.
- Generate a **large amount of sludge**.
- Repeated addition of bacteria/enzyme is required for the process.
- Maintenance & recurring cost is high.

The Advantages of Anaerobic Biodegradation

- No aeration is required.
- Complete anaerobic conditions.
- More than 99% pathogen inactivation.
- Anaerobes **can even degrade detergents/phenyl**.
- Sludge generation is very less.
- One-time bacterial inoculation is enough.
- Minimal maintenance and no recurring cost.

EcoSan toilets

- **Ecological sanitation** is a sustainable system for handling human excreta, using **dry composting toilets**.
- This is a practical, hygienic, efficient, and cost-effective solution to human waste disposal.
- With this composting method, human excreta can be recycled into a resource (as natural fertiliser).

20.2.4. Swachh Bharat Mission

- SBM was Launched on 2nd October 2014.
- It seeks to achieve universal sanitation coverage by making Gram Panchayats Open Defecation Free (ODF).
- SMB is implemented by the **Ministry of Drinking Water and Sanitation**.
- Incentives as provided for all BPL Households and Above Poverty Line (APL) households restricted to SCs/STs, physically handicapped and women headed households for the construction of household latrines.
- The incentives are provided by the Centre and States **(75% : 25%)**.
- For North-eastern State, and Special category States, the Central share will be 90%.

Performance of the mission

- In 2014, the sanitation coverage in the country was reported at 38.7 per cent.
- More than 10 crore individual toilets have been constructed since the launch of the mission.
- **Rural areas in all the states have declared themselves ODF as on 2ndOctober, 2019**.

Swachh Iconic Places

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- Swachh Iconic Places (SIP) is an initiative of **Ministry of Drinking Water and Sanitation** under SBM.
- Aims to take iconic places and their surroundings to higher standards of Swachhata.

Implementation

- It is a collaborative project with three other central Ministries: **Urban Development, Culture, Tourism** and concerned States.
- Initiatives taken up under Swachh Iconic Places initiative are:
  - ✓ Improved sewage infrastructure,
  - ✓ improved sanitation facilities,
  - ✓ water vending machines,
  - ✓ solid and liquid waste management (SLWM)
  - ✓ lighting arrangements, beautification of parks, roads maintenance,
  - ✓ better transport facilities in approach and access areas besides at the main sites.

Places selected for implementation

Phase I

- Ajmer Sharif Dargah, CST Mumbai, Golden Temple, Kamakhya Temple, MaikarnikaGhat, Meenakshi Temple, Shri Mata Vaishno Devi, Shree Jagannath Temple, The Taj Mahal and Tirupati Temple.

Phase II

- Gangotri, Yamunotri, Mahakaleshwar Temple, Charminar, Convent and Church of St. Francis of Assissi, Kalady, Gommateswara, BaidyanathDham, Gaya Tirth and Somnath temple.

Phase III

- Raghavendra Swamy Temple (Kurnool, Andhra Pradesh);
- Hazardwari Palace (Murshidabad, West Bengal);
- Brahma Sarovar Temple (Kurukshetra, Haryana);
- VidurKuti (Bijnor, Uttar Pradesh);
- Mana village (Chamoli, Uttarakhand);
- Pangong Lake (Leh-Ladakh, J&K);
- Nagvasuki Temple (Allahabad, Uttar Pradesh);
- ImaKeithal/market (Imphal, Manipur);
- Sabarimala Temple (Kerala); and
- Kanvashram (Uttarakhand).

Locate these places on a Map

20.2.5. Swachh Bharat Mission II

- GOI has approved the second phase of the Swachh Bharat Mission (SBM II).
- The estimated central and state budget for SBM II is ~Rs 52,000 crore.
- The second phase will be implemented between **2020-21 and 2024-25**.
- The second phase will focus on **Open Defecation Free Plus (ODF Plus)**, which includes **ODF sustainability** and **solid and liquid waste management(SLWM)**.
- The ODF Plus will converge with MGNREGA, especially for grey water management, and will complement the newly launched **Jal Jeevan Mission**.
- The fund sharing pattern between the Centre and States will be

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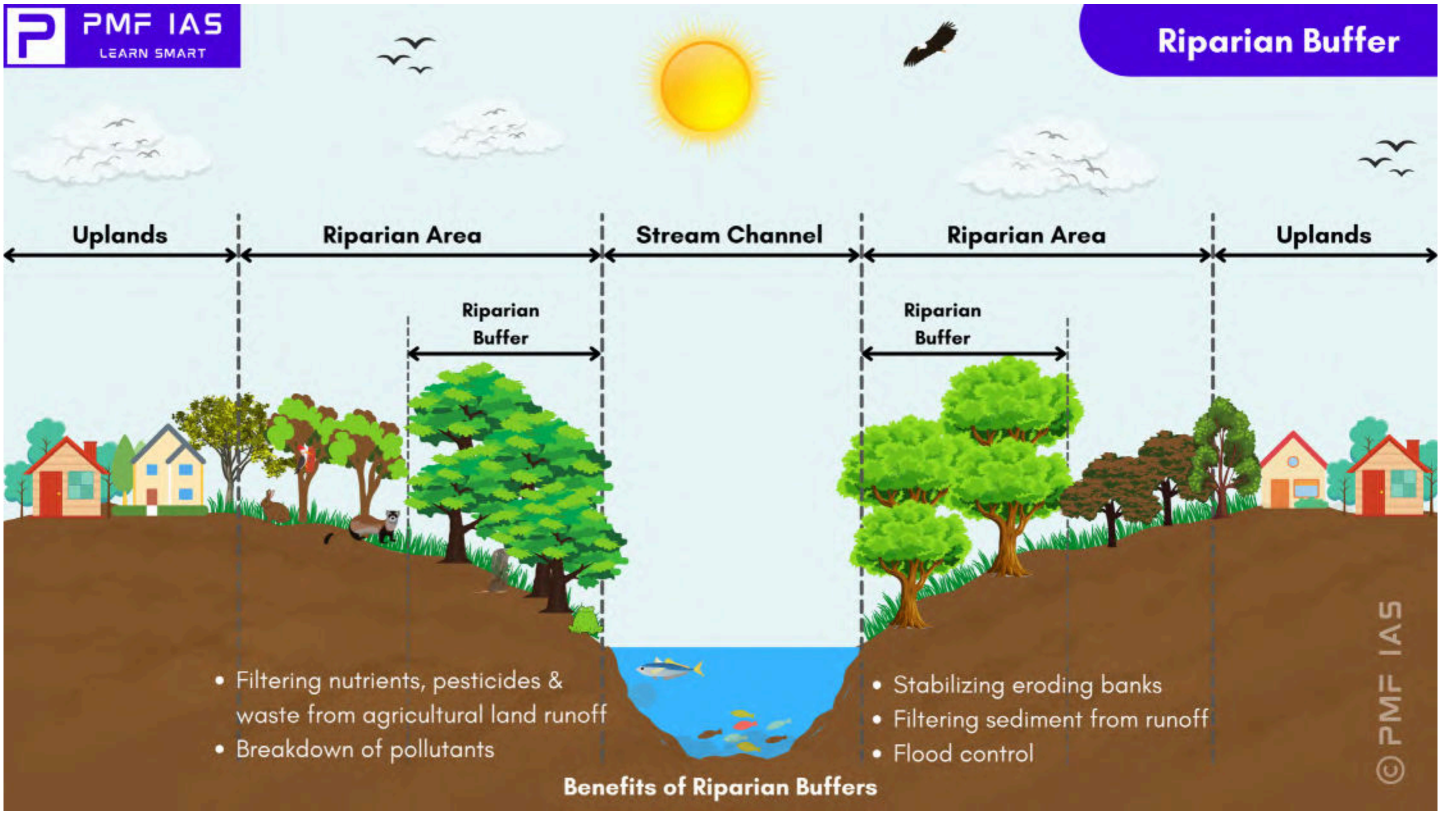
- ✓ 90:10 for North-Eastern States and Himalayan States and UT of J&K;
- ✓ **60:40 for other States**; and
- ✓ 100:0 for other Union Territories.

20.2.6. Riparian buffers for Mitigation of Eutrophication

- Treating industrial effluents and domestic sewage to remove nutrient-rich sludge through wastewater processing.
- **Riparian buffer:** Interfaces between a flowing body of water and land created near the waterways, farms, roads, etc. in an attempt to filter pollution.
- Sediments and nutrients are deposited in the buffer zones instead of deposition in water (**wetlands, estuaries are natural riparian buffers**).
- Increase in efficiency of nitrogen & phosphorous fertilisers and using them inadequate levels.
- Nitrogen testing & modelling: **N-Testing** is a technique to find the optimum amount of fertiliser required for crop plants. It will reduce the amount of nitrogen lost to the surrounding area.
- Encouraging organic farming.
- Reduction in nitrogen emission from vehicles and power plants.



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21. Radioactive Pollution

- Radioactive Pollution is defined as the increase in the radiation levels in the environment that pose a serious threat to humans and other life forms.
- **Radioactive contamination** is the presence of radioactive substances on surfaces or within solids, liquids or gases, where their presence is unintended or undesirable — International Atomic Energy Agency.
- The use of nuclear energy has two inherent problems:
  1. Accidental leakage — as occurred in the **Three Mile Island, Chernobyl,** and **Fukushima incidents** and
  2. Safe disposal of radioactive wastes.
- At high doses, nuclear radiation is lethal, but at lower doses, it creates various disorders, the most frequent of all being cancer.
- Continued small dose exposure to nuclear radiation can cause **childhood leukaemia, miscarriage, underweight babies, infant deaths, increased susceptibility to AIDS and other immune disorders**.
- **Artificial Sources of Radioactive pollution:**
  - ✓ Accidents in nuclear power plants & nuclear waste.
  - ✓ Nuclear weapon testing & nuclear fallout.
  - ✓ The fall out contains radioactive substances such as **strontium-90, caesium-137, iodine-131**, etc.
  - ✓ Mining of radioactive material like **Uranium** and **thorium (monazite is the ore of thorium)**.
  - ✓ Exposure to radiation for diagnostic purposes (e.g. **X-rays, CT Scan**), chemotherapy etc.
  - ✓ The slow nuclear radiations can emanate from a variety of sources viz. nuclear reactors, laboratories, etc.
- **Natural Sources:** They include **cosmic rays** from space and terrestrial radiations from **radionuclides** present in earth's crust such as **radium-224, uranium-238, thorium-232, potassium-40, carbon-14**, etc.

21.1. Ionizing and Non-Ionizing Radiation

- Radioactivity is a phenomenon of spontaneous emission of **proton (alpha-particles)**, **electrons (beta-particles)** and **gamma rays (short wave electromagnetic waves)** due to the **disintegration of atomic nuclei** of some elements. These cause radioactive pollution.
- Radiations can be categorized into two groups namely the **non-ionizing radiations** and the **ionising radiations**.

21.2. Non-Ionizing Radiation

- Non-ionizing radiations are constituted by the electromagnetic waves at the **longer wavelength of the spectrum** ranging from **long wavelength radiations (UV)** to **radio waves** (includes **microwaves**).
- These waves have enough energy enough to **excite the atoms and molecules of the medium** through which they pass, **causing them to vibrate faster** but **not strong enough to ionise them**.
- They may damage eyes which may be caused by **reflections from coastal sand**, snow (**snow blindness**) directly looking towards the sun during an eclipse.
- They injure the cells of skin and blood capillaries producing blisters and reddening called sunburns.

⇨ *In a **microwave oven**, the radiation causes **water molecules in the cooking medium to vibrate faster** and thus raising its temperature.*

21.2.1. Impact of Non-Ionizing Radiation from Mobile Phone Towers

- The radiation that comes from mobile tower radiation is **non-ionizing radiation**.

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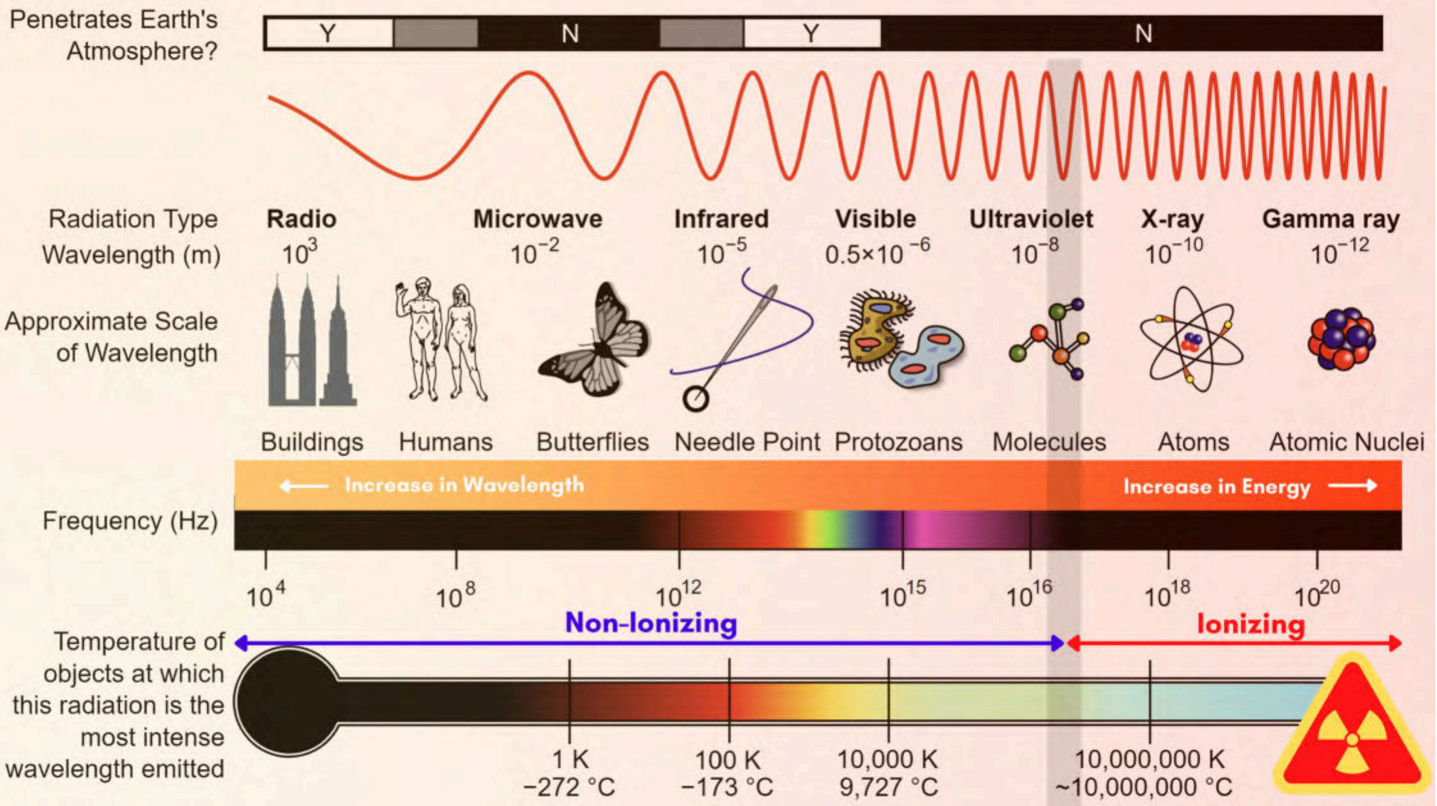
Health Impacts

- Every antenna on a cell phone tower radiates **electromagnetic radiation (EMR)**.
- When one cell phone tower is used by a number of operators, more will be the number of antennas and more is the power intensity in the nearby area.
- The power level near towers is higher and reduces as we move away.
- EMR may cause cellular & psychological changes in human beings due to **thermal effects** that are generated due to the **absorption of microwave radiation**.
- The exposure can lead to **genetic defects, effects on reproduction** and development, **Central Nervous System** behaviour etc.
- EMR can also cause **non-thermal effects** which are caused by **radio frequency fields** at levels too low to produce significant heating and are due to **movement of calcium and other ions across cell membranes**.
- Such exposure is known to be responsible for fatigue, nausea, irritability, headaches, loss of appetite and other psychological disorders.
- The current exposure safety standards are purely based on the thermal effects considering few pieces of evidence from exposure to non-thermal effects.

Impact on birds

- The **surface area of a bird is relatively larger** than their body weight in comparison to the human body, **so they absorb more radiation**.
- Also, the **fluid contained in the body of the bird is less** due to small body weight, so it gets heated up quickly.
- The magnetic field from the towers **disturbs birds' navigation skills**; hence when birds are exposed to EMR **they disorient** and begin to fly in all directions.
- Many birds die each year from collisions with telecommunication masts.



21.3. Ionising Radiation

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- Ionising radiations cause **ionisation (one or more electrons are pealed out from the outer shells of an atom) of atoms and molecules** of the medium through which they pass.

⇨ ***Ionisation*** *is the process by which an atom or a molecule* ***acquires a negative or positive charge*** *by gaining or losing electrons to form ions, often in conjunction with other chemical changes.*

- Electromagnetic radiations such as **short wavelength ultraviolet radiations** (**UV**), **X-rays** and **gamma rays** and **energetic particles** produced in nuclear processes, electrically charged particles like **alpha and beta particles** produced in **radioactive decay** and **neutrons** produced in nuclear fission, are highly damaging to living organisms.
- Electrically charged particles produced in the nuclear processes can have **sufficient energy to knock electrons out of the atoms or molecules of the medium, thereby producing ions**.
- The ions produced in water molecules, for example, can induce reactions that can **break bonds in proteins** and other important molecules.
- An example of this would be when a **gamma ray** passes through a cell, the **water molecules near the DNA might be ionised** and the **ions might react with the DNA causing it to break**.
- They can also cause chemical changes by breaking the chemical bonds, which can damage living tissues.
- Short range effects include burns, impaired metabolism, dead tissues, and death of the organisms.
- Long range effects are **mutations** increased the incidence of **tumours and cancer**, shortening of life-span and developmental changes.

⇨ ***Non-ionizing radiations*** *have* ***low penetrability*** *and* ***affect only those components*** *which* ***absorb them****.*

⇨ ***Ionising radiations have high penetration power and cause breakage of macromolecules****.*

21.3.1. Biological Damage Due to Ionizing Radiation

- Radiation damage can be divided into two types: (a) **somatic damage** (also called **radiation sickness**) and (b) **genetic damage**.
- **Somatic damage** refers to damage to **cells that are not associated with reproduction**.
- Effects of somatic radiation damage include loss of hair, **fibrosis of the lungs**, a **reduction of white blood cells**, and the induction of **cataract in the eyes**. This damage can also result in cancer and death.
- **Genetic damage** refers to damage to **cells associated with reproduction**.
- This damage can subsequently cause genetic damage from **gene mutation** resulting in abnormalities.
- Genetic damages are passed on to the next generation.

21.3.2. Radiation Dose

- A traditional unit of human-equivalent dose is the **rem**, which stands for radiation equivalent in man.
- At low doses, such as what we receive every day from background radiation (<1 m rem), the cells repair the damage rapidly.
- At higher doses (up to 100 rem), the cells might not be able to repair the damage, and the cells may either be changed permanently or die. E.g., **radiation sickness**.
- Cells changed permanently may go on to produce abnormal cells when they divide and may become **cancerous**.

21.3.3. The Damage Potential of Radiation Particles

- **Alpha particles** can be blocked by a piece of paper and human skin.
- **Beta particles** can penetrate through the skin, while they can be blocked by some pieces of glass & metal.
- **Gamma rays can penetrate easily** through human skin and damage cells on its way through, reaching far, and **can only be blocked by a very thick, strong, massive piece of concrete**.

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Half-Life – Period of Radioactivity

- Each radioactive material has a **constant decay rate**.
- Half-life is the time needed for **half of its atoms to decay**.
- The half-life may vary from a fraction of a second to thousands of years.
- The radionuclides with **long half-time** are the chief source of environmental radioactive pollution.

21.4. Accidents at Nuclear Power Plants

- **Nuclear fission** in the reactor core produces a lot of heat which if not controlled can lead to a **meltdown of fuel rods in the reactor core**.
- If a meltdown happens by accident, it will release large quantities of highly dangerous radioactive materials in the environment with disastrous consequences to the humans, animals, and plants.
- To prevent this type of accidents and reactor blow up, the reactors are designed to have a number of safety features.
- Inspire of these safety measures three disasters in the nuclear power plants are noteworthy – **Three Mile Island' in Middletown (U.S.A.) in 1979**, **Chernobyl (U.S.S.R.) in 1986** and **Fukushima Daiichi nuclear disaster in 2011**.
- In the first two cases, a series of mishaps and errors resulted in **overheating of the reactor core** and a lot of radiation was released into the environment.
- The leakage from the Three Mile Island reactor was low, and no one was injured immediately.
- However, in the case of **Chernobyl**, the leakage was very heavy causing the death of many workers and **radiation spread over large areas scattered all over Europe**.
- The latest one – **Fukushima Daiichi nuclear accident** was **triggered by an earthquake**.

21.5. Safe Disposal of Nuclear Wastes

- Radioactive wastes are of two types:
  1. **low-level radioactive wastes (LLW)** which include civilian applications of radionuclides in medicine, research and industry, materials from decommissioned reactors, protection clothing worn by persons working with radioactive materials or working in nuclear establishments.
  2. **High-level radioactive wastes (HLW)** results from **spent nuclear fuel rods** and **obsolete nuclear weapons**.

21.5.1. Some Proposed Methods of Disposing Nuclear Waste

- Bury it deep underground in insulated containers. This is a strategy being pursued in the United States.
- Shoot it into space or the sun. The cost would be extremely high, & a launch accident should be disastrous.
- Bury it under the ice sheet of Antarctica or Greenland ice cap. The ice could be destabilised by heat from the waste. The method has been prohibited by international law.
- Dump it into deep oceans by keeping the waste into glass and steel cases. But the containers might leak and contaminate the ocean.
- Change it into harmless or less harmful isotopes. Currently, no method is known to do that, and the method would be too costly.
- Presently **waste fuel rods** are being stored in special storage ponds at reactor sites or sent to reprocessing plants.
- Even though reprocessing is more expensive, but some countries use reprocessing as an alternative to waste storage.

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22. Solid Wastes

- Solid wastes or municipal solid wastes generally **comprise paper, food wastes, plastics, glass, metals, rubber, leather, textile, etc.**
- Solid waste management is a term that is used to refer to the process of **collecting & treating solid wastes.**
- It also offers solutions for recycling items that do not belong to garbage or trash.
- Open burning reduces the volume of the wastes, although it is generally **not burnt to completion** & **open dumps** often serve as the breeding ground for rats and flies.
- **Sanitary landfills** were adopted as the substitute for open-burning dumps. In a sanitary landfill, **wastes are dumped in a depression or trench after compaction** & covered with dirt every day.
- Landfills are also not much of a solution since the amount of garbage generation especially in the metros has increased so much that these sites are getting filled too.
- Also, there is a danger of seepage of chemicals, etc. from these landfills **polluting the underground water resources.**

22.1. Sources of Solid Waste

22.1.1. Industrial solid wastes

- Thermal power plants producing **coal ash/fly ash** **(fly ash in concrete increases the life of roads)**;
- The integrated iron and steel mills producing blast **furnace slag** **(can be used in portland cement concrete, road and railway construction, soil conditioning);**
- Non-ferrous industries like aluminium, copper and zinc producing **red mud** **(can be used in construction material in bricks, blocks, light weight aggregates, roofing tiles, etc);**
- Sugar industries generating **press mud** **(can be used as soil conditioner, soil fertilizer)**;
- Pulp and paper industries producing **lime mud** **(can be used in bricks, cement, wastewater treatment, and agricultural soils)**;
- Fertilizer and allied industries producing **gypsum** **(can be used to treat soil alkalinity; used in portland cement** and **plaster of paris (POP))**;

Q. Steel slag can be the material for which of the following? (2020)

1. Construction of base road
2. Improvement of agricultural soil
3. Production of cement

Select the correct answer using the code given below:

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: a) all

Inadequate Infrastructure

- According to the 12th Schedule of the 74th Constitution Amendment Act of 1992, urban local bodies (ULBs) are responsible for keeping cities and towns clean.

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- However, most ULBs lack adequate infrastructure and face various strategic and institutional weaknesses, such as poor institutional capacity, financial constraints, and a lack of political will.

22.1.2. Residential and Commercial Waste

- Residences and homes where people live are some of the major sources of solid waste.
- The garbage from these places includes **food wastes, plastics, paper, glass, leather, household items such as electronics, tires, batteries, old mattresses and used oil.**

Commercial Waste

- Commercial facilities & buildings are yet another source of solid waste today.
- Some of the solid wastes generated from these places include **plastics, food wastes, metals, paper, glass, wood, cardboard materials, special wastes.**

Construction & Demolition Sites

- Construction and demolition sites also contribute to the solid waste problem.
- Construction sites include new construction sites for buildings and roads, road repair sites, building renovation sites and building demolition sites.
- Some of the solid wastes produced in these places include **steel materials, concrete, wood, plastics, rubber, copper wires, dirt and glass**.

22.1.3. Bio-Medical Waste

- This refers to hospitals & biomedical equipment & chemical manufacturing firms.
- In hospitals, there are different types of solid wastes produced.
- Some of these solid wastes include **syringes, bandages, used gloves, drugs, paper, plastics, food wastes and chemicals.**
- All these require proper disposal or else they will cause a huge problem for the environment and the people in these facilities.

22.1.4. Plastics and Micro-Plastics

- The researchers found huge amounts of microplastics in the Arctic snow.

The Plastic problem

- Up to 12 million tonnes of plastics are thought to enter the world's oceans every year.
- Plastic fragments were found even in the guts of animals living more than 10 km below the ocean surface.
- Several recent studies have established the presence of **microplastics in groundwater** in the US.
- A study estimated that the average human ends up consuming at least 50,000 particles of microplastics in food every year.

Microplastics

- Microplastics are defined as shreds of plastic less than 5 mm in length.
- Microplastics come from a variety of sources, including from larger plastic debris.
- **Microbeads**, a type of microplastic (tiny pieces of polyethylene), are very tiny pieces of plastic that **are added to health and beauty products, such as some cleansers and toothpastes (cooling crystals)**.
- Even so, manufactured microbeads are **not a major contributor to microplastic pollution**.
- One of the main contributors to this pollution, instead, is plastic waste, 90% of which is not recycled.

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- However, their impact on **tiny marine organisms** is significant since their injection leaves them starved.

Q. Why is there a great concern about the microbeads that are released into environment?

a) They are considered harmful to marine ecosystem
b) They are considered to cause skin cancer in children
c) They are small enough to absorbed by crop plants in irrigated fields
d) They are often found to be used as food adulterants

Answer: a)

Microplastics in drinking water not a health risk for now

- In its first report into the effects of microplastics on human health, WHO aid the level of microplastics in drinking-water is **not yet dangerous for humans** but called for more research into potential future risk.
- WHO said that **microplastics larger than 150 micrometres** are **not likely to be absorbed by the human body** but the chance of absorbing very small microplastic particles (nano-sized plastics) could be higher.

Plastic waste in road construction

- **Polyblend** is a fine powder of recycled and modified plastic waste.
- This mixture is mixed with the **bitumen** that is used to lay roads.
- Blends of **Polyblend &bitumen**, when used to lay roads, **enhanced the bitumen's water repellent properties**, and helped to increase road life by a factor of three.

22.2. Effects of Plastic Waste

22.2.1. Impact on Environment

- Conventional plastics, right from their manufacture to their disposal are a major problem to the environment.
- The land gets littered by plastic bag garbage and becomes unhygienic.
- Conventional plastics have been associated with **reproductive problems** in both humans and wildlife.
- **Dioxin** (**highly carcinogenic and toxic**) by-product of the manufacturing process is one of the chemicals believed to be passed on through **breast milk** to the nursing infant.
- Burning of plastics, especially **PVC** releases **dioxin** & **furan** into the atmosphere.
  - ⇨ ***Dioxins are environmental pollutants**. They belong to the so-called **"dirty dozen"** – a group of dangerous chemicals known as **persistent organic pollutants (POPs)**.*
  - ⇨ *The name "dioxins" is often used for the family of structurally and chemically related **polychlorinated dibenzo para dioxins (PCDDs)** and **polychlorinated dibenzofurans (PCDFs)**.*
- Plastic bags can also contaminate foodstuffs due to **leaching of toxic dyes & transfer of pathogens.**
- Careless disposal of plastic bags chokes drains, blocks the porosity of the soil & causes **problems for groundwater recharge.**
- Plastic **disturbs the soil microbe activity**. The terrestrial and aquatic animals misunderstand plastic garbage as food items, swallow them and die.
- Plastic bags **deteriorate soil fertility** as it forms part of manure and remains in the soil for years.

22.2.2. Other Impacts

- **Health:** Exposure to wastes that handled improperly can cause skin irritations, respiratory problems, blood infections, growth problems & even reproductive issues.

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- **Soil & Ground Water Pollution**
- **Land & Aquatic Animals:** Consuming **styrofoam a**nd cigarette butts have been known to cause deaths in marine animals. Animals are also at risk of poisoning while consuming grasses near contaminated areas or landfills as the toxins seep into the soil.

22.3. Issues with Treatment & Disposal of Solid Waste

22.3.1. Open dumps

- Open dumps refer to uncovered areas that are used to dump **solid waste of all kinds.**
- The **waste is untreated, uncovered & not segregated**.
- It is the breeding ground for flies, rats, and other insects that spread disease.
- The rainwater runoff from these dumps contaminates nearby land and water thereby spreading disease.

Inadequate Infrastructure

- According to the 12th Schedule of the **74th Constitution Amendment Act of 1992**, urban local bodies (ULBs) are responsible for keeping cities and towns clean.
- However, most ULBs lack adequate infrastructure and face various strategic and institutional weaknesses, such as poor institutional capacity, financial constraints, and a lack of political will.

22.3.2. Landfills

- It is a pit that is **dug in the ground.**
- The garbage is dumped, & the **pit is covered with soil every day** thus preventing the breeding of flies and rats.
- After the landfill is full, the area is covered with a thick layer of mud & the **site can thereafter be developed** as a parking lot or a park.
- **All types of waste are dumped in landfills**, and when water seeps through them it gets contaminated and in turn, pollutes the surrounding area.
- This contamination of groundwater and soil through landfills is known as **leaching.**

22.3.3. Sanitary landfills

- Sanitary landfill is **more hygienic & built methodically** to solve the problem of leaching.
- These are **lined with materials that are impermeable** such as plastics and clay and are also built over impermeable soil.
- Constructing a sanitary landfill is **very costly**.

22.3.4. Incineration plants

- The process of **burning waste in large furnaces** at high temperature is known as **incineration**.
- In these plants, the recyclable material is segregated, and the rest of the material is burnt.
- Burning garbage is **not a clean process** as it produces tonnes of toxic ash and pollutes the air and water.
- At present, incineration is kept as the last resort and is **used mainly for treating infectious waste**.

22.3.5. Pyrolysis

- It is a process of combustion in the **absence of oxygen**, or the material burnt under a **controlled atmosphere of oxygen**.
- It is an **alternative to incineration.**

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- The **gas** & **liquid** thus obtained can be used as fuels.
- Pyrolysis of carbonaceous wastes like firewood, coconut, palm waste, corn combs, cashew shell, rice husk paddy straw and sawdust, yields **charcoal** along with products like **tar, methyl alcohol, acetic acid, acetone** and **fuel gas**.

Q. In the context of which one of the following are the terms pyrolysis and plasma gasification mentioned? (2019)

a) Extraction of earth element
b) natural gas extractions technologies
c) Hydrogen fuel-based automobiles
d) Waste to energy technologies

Explanation:

- **Plasma gasification** is an extreme thermal process using plasma which converts **organic matter** into a **syngas** which is primarily made up of **hydrogen** and **carbon monoxide**.

Answer: d)

22.3.6. Composting

- Composting is a **biological process** in which micro-organisms, mainly **fungi and bacteria,** decompose degradable **organic waste into humus-like substance** in the presence of oxygen.
- This finished product, which looks like soil, is high in **carbon and nitrogen** & is an excellent medium for growing plants.
- It increases the soil's ability to hold water & makes the soil easier to cultivate. It helps the soil retain more plant nutrients.

22.3.7. Vermiculture

- It is also known as **earthworm farming.**
- In this method, Earthwormsare added to the compost.
- These worms break the waste & the added excreta of the worms make the **compost very rich in nutrients.**

22.3.8. Waste to Energy Plant

- Waste-to-Energy is the process of generating energy in the **form of electricity and/or heat from the waste**.
- **Step1:** Segregation of biodegradable or wet waste from dry waste at source.
- **Step 2:** Municipalities can use wet waste to produce compost & biogas in bio methanation plants.
- **Step 3:** The dry waste, after removing recyclable elements, goes to waste-to-energy plants.
- The inorganic material is processed as **Refuse Derived Fuel** (RDF: calorific value: 2,500 kJ/kg).
- This waste (RDF), usually taken from industrial or commercial sites, is burned to produce electricity.
- **Refuse Derived Fuel is a renewable energy source** that ensures waste simply is not thrown into a landfill.

Advantages of WTE plants

- Dependence on **Fossil fuels & Foreign countries** will be reduced.
- **Dual purpose will be served** i.e. -waste to energy & reduction in the volume of waste for disposal.
- Area required for waste disposal will be minimised.
- Energy obtained is clean & renewable.

Challenges associated with Waste-to-Energy plants in India

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1. Cost of Operation is high because India is heavily dependent on foreign countries for technology.
2. **Nature of Waste:** WTE plants require fine inorganic material with **less than 5% moisture & less than 5% soil contents**, whereas the moisture and inert content in Indian Municipal Solid Waste is 15%-20%.
3. **Segregation at Source**: Since segregation at source doesn't happen in the city, the collected waste material needs to be sieved which adds up to the additional costs.
4. **Low Calorific value for electricity generation**: silt and soil particles can reduce the calorific value.
5. **Power tariff**: the tariff at which the power is purchased by WTE plants is around ₹7-8 KwH which is higher than the ₹3-4 per KwH generated through coal and other means.

22.4. Measures Taken to Manage Solid Waste

22.4.1. Solid Waste Management Rules (2016)

- These replace the Municipal Solid Wastes (Management and Handling) Rules, 2000.
- These Rules are now applicable **beyond Municipal areas and extend to urban agglomerations**.
- **Responsibilities of Generators** have been introduced to segregate waste in to **3 streams** before handing it over to the collector:
  1) **Wet (Biodegradable)**
  2) **Dry (Plastic, Paper, metal, wood, etc.)**
  3) **Domestic hazardous wastes** (diapers, napkins, empty containers of cleaning agents, mosquito repellents, etc.)

Segregation at Source

- **Source segregation of waste** has been mandated to channelize the **waste to wealth by recovery, reuse and recycle**.
- In case of an event or **gathering of more than 100 persons at any licensed / unlicensed place**, the organizer will have to ensure segregation of waste at source and handing over of segregated waste to waste collector or agency, as specified by the local authority.
- **All hotels and restaurants** will also be required to segregate biodegradable waste & set up a system of collection to ensure that such food waste is utilized for **composting / biomethanation**.
- The rules mandate that all resident welfare and market associations and gated communities with an **area of above 5,000 sq m** will have to segregate waste at
- They have to hand over recyclable material to authorized pickers and recyclers or to the urban local body.

Collect Back scheme for packaging waste

- Brand owners who sale or **market their products in packaging material which are non-biodegradable**, should put in place a system to collect back the packaging waste generated due to their production.

User Fees for Collection

- **Municipal authorities** will levy user fees for collection, disposal and processing from bulk generators.
- As per the rules, the generator will have to pay **"User Fee"** to the waste collector & a **"Spot Fine"** for littering & non-segregation, the quantum of which will be **decided by the local bodies**.

Waste Processing & Treatment

- Bio-degradable waste should be processed and disposed of through **composting or biomethanation.**
- Rules have mandated bioremediation or capping of old and abandoned dump sites **within 5 years**. Waste processing facilities will have to be set up by **local bodies:**

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1. **Population of 1 million or more –** Within **2 years**.
2. **Population below 1 million –** Within **3 years**.
3. **Population under 0.5 million**

Promotion of Waste to Energy

- It mandates all industrial units using fuel & located within **100 km from a solid waste-based Refuse-Derived Fuel (RDF) Plant** to make arrangements within six months from the date of notification to replace at least 5 per cent of their fuel requirement by RDF so produced.
- **Ministry of New and Renewable Energy** should facilitate infrastructure creation for Waste to Energy plants and provide appropriate subsidy or incentives for such Waste to Energy plants.

Revision of Parameters

- **Landfill site** shall be 100 meters away from a river, 200 meters from a pond, 500, 200 meters away from highways, habitations, public parks and water supply wells and 20 km away from airports/airbase.
- **Emission standards are completely amended** and include parameters for **dioxins, furans**, reduced limits for particulate matters from 150 to 100 and now 50.
- Also, the compost standards have been amended to align with **Fertilizer Control Order**.

Q. As per the Solid Waste Management Rules, 2016 in India, which one of the following statements is correct?

a) Waste generator has to segregate waste into 5 categories.
b) The Rules are applicable to notified urban local bodies, notified towns and all industrial township only.
c) The Rules provide for exact and elaborate criteria for the identification of sites for landfills and waste processing facilities.
d) It is mandatory on the part of waste generator that the waste generated in one district cannot be moved to another district.

Answer: c)

Constitution of Central Monitoring Committee

- Central Monitoring Committee under the **chairmanship of Secretary, MoEF** to monitor the **overall implementation of the rules**.

Promoting Use of Compost

- **Ministry of Chemicals and Fertilizers** should provide market development **assistance on city compost.**
- **Ministry of Agriculture** should provide flexibility in Fertilizer Control Order for manufacturing & sale of compost, propagating use of compost on farm land.

Some other features

- Integration of **rag pickers**, waste pickers and kabadiwalas from the informal sector to the **formal sector** by the state government.
- Zero tolerance for throwing, burning the solid waste generated on streets, open public spaces outside the generator's premises, or in the drain, or water bodies.
- The manufacturers or brand owners of sanitary napkins are responsible for awareness for proper disposal of such waste by the generator.
- Land for construction of sanitary landfills in hilly areas will be identified in the plain areas, within 25 kilometers.

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22.4.2. Bio-Medical Waste (Management and Handling) Rules, 2016

- Biomedical waste comprises human & animal anatomical waste and treatment apparatus like needles used in health care facilities (HCF – hospitals, laboratories, blood banks, immunization programmes).
- Bio-Medical Waste Management Rules 2016 is an improvement to 1998 rules.

Salient features of BMW Management Rules, 2016

- Phase-out the use of **chlorinated** plastic bags, gloves and blood bags within two years.
- Pre-treatment of the laboratory waste, microbiological waste, blood samples through sterilization on-site.
- Establish a Bar-Code System for bags or containers containing bio-medical waste for disposal.
- Bio-medical waste has been classified in to **4 categories** instead 10 to improve segregation of waste at source.
- State Government to provide land for setting up common bio-medical waste treatment and disposal facility.
- No occupier shall establish on-site treatment and disposal facility, if a service of it is available at a distance of seventy-five kilometre.
- Operator of a common bio-medical waste treatment and disposal facility to ensure the timely collection of bio-medical waste from the HCFs.
- Vaccination camps, blood donation camps, etc. will come under the ambit of these rules.

Procedure to be followed

- The hospitals are required to put in place the mechanisms for effective disposal either directly or through common biomedical waste treatment and disposal facilities.
- The hospitals servicing 1000 patients or more per month are required to obtain authorization and segregate biomedical waste into categories as specified by the rules.
- For example, syringes, needles and blood-soiled bandages should be all disposed of in a **red coloured bag or bin**, where it will later be incinerated (destroy by burning). If body fluids are present, the material needs to be **incinerated**.

Problems of unscientific Bio-medical waste disposal

- 85% of the hospital waste is non-hazardous, 15% is infectious/hazardous.
- **Mixing of hazardous and non-hazardous waste** makes the entire waste hazardous.
- Improper disposal can lead to many diseases in animals as well as humans.
- It encourages recycling of prohibited disposables and drugs which will further spread infections.
- It also develops **resistant microorganisms (antimicrobial resistance)**.

Common Bio-Medical Waste Treatment Facilities

- Currently, in India, there are around 200 Common Bio-Medical Waste Treatment Facilities (CBMWTFs) in operation which is inadequate.
- Central Pollution Control Board (CPCB) has marked Common Bio-Medical Waste Treatment Facilities (CBWTFs) as a key factor in the race to contain the coronavirus outbreak.
- CPCB's order mandates that Isolation wards, sample collection centres, and laboratories are all mandated to keep a separate 'COVID-19' waste collection bin in a temporary storage room.
- CBWTFs are to identify this separately-labelled waste for priority treatment and disposal.
- According to NGT even though 20 years had passed since the SC issued directions on dealing with solid waste management, no progress was made by states.

22.4.3. Waste Minimization Circles (WMC)

- WMC helps Small and Medium Industrial Clusters in waste minimisation in their industrial plants.

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- This is assisted by the **World Bank** with the MoEF acting as the nodal ministry.
- The project is being implemented with the assistance of the **National Productivity Council, New Delhi**.
- The initiative aims to realise the objectives of the Policy Statement for Abatement of Pollution (1992), which states that the **government should educate citizens** about environmental risks, the economic and health dangers of resource degradation and the real economic cost of natural resources.
- The policy also recognises that citizens and non-governmental organisations play a role **in environmental monitoring**, therefore, enabling them to supplement the regulatory system.

22.4.4. Composite Waste Management Index: 2.0

- It is released by **NITI Aayog**.
- Index is an attempt to **inspire states & UT's** toward efficient & **optimal utilization of water**.
- Index provides useful information for states & also for concerned central ministries/departments.
- **State Ranking:**
  1. Gujarat
  2. Andhra Pradesh
- Union Territories for the first time submitted their data in CMMI 2.0. **Puducherry** declared top ranker.
- 80% of states assessed on Index are improving.

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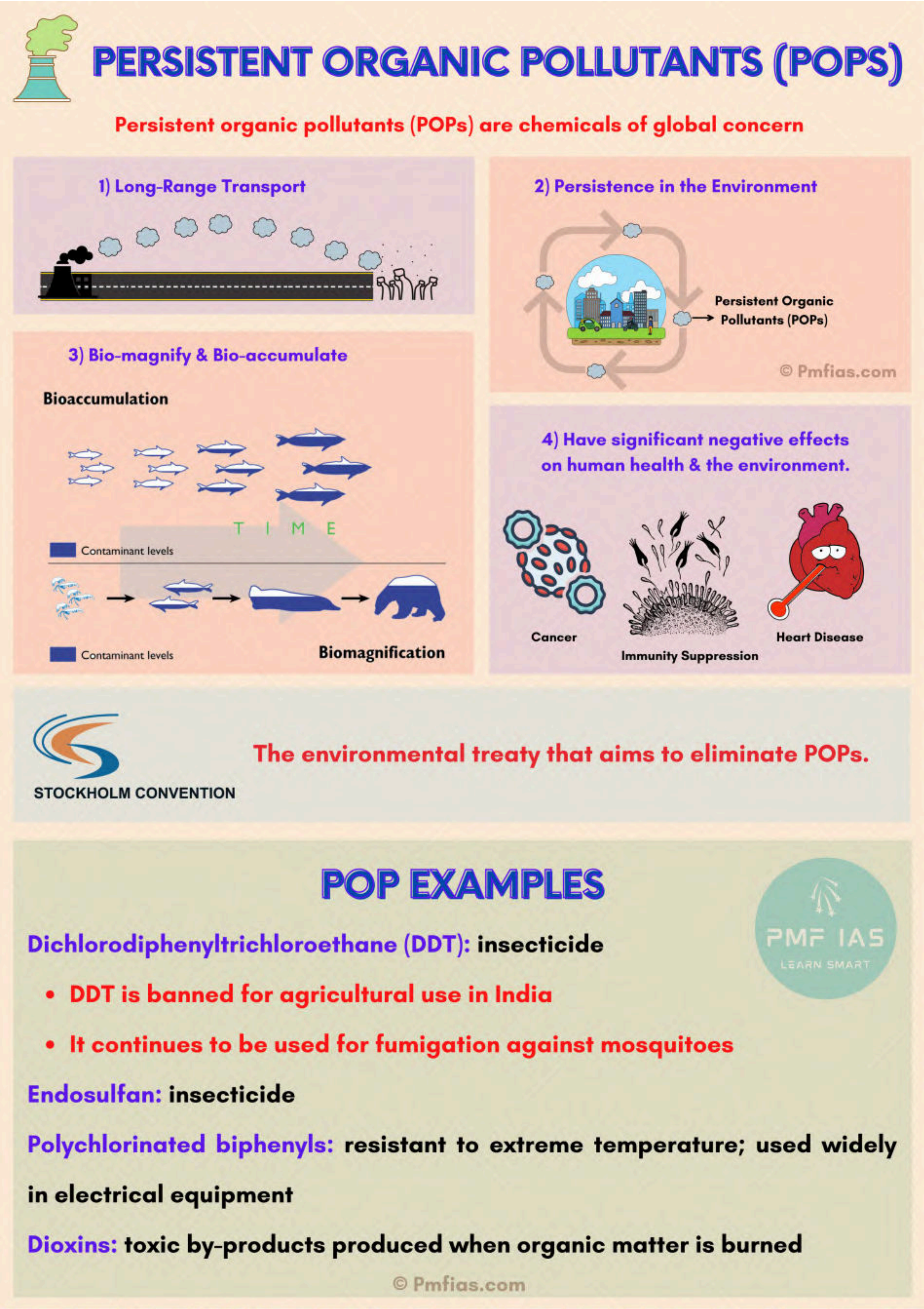
23. Hazardous Waste



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- Any substance that is present/released in the environment and causes **substantial damage** to public health and **welfare of the environment** is called hazardous substance.
- Any hazardous substance could exhibit any one or more of the following characteristics: **toxicity, ignitability, corrosivity or reactivity** (explosive).
- Thus, any waste that contains hazardous or very hazardous substance is called hazardous waste.
- Hazardous wastes can originate from various sources such ashousehold, local areas, urban, industry, agriculture, construction activity, hospitals and laboratories, power plants and other sources.

23.1. Persistent Organic Pollutants (POPs)

- **POPs** are defined as "chemical substances that persist in the environment, bioaccumulate through the food web, & pose a risk of causing adverse effects to human health & the environment".
- Persistent organic pollutants (POPs) are chemicals of global concern due to their potential for:
  - ✓ **long-range transport,**
  - ✓ **persistence in the environment,**
  - ✓ **ability to** bio-magnify & bio-accumulate **in ecosystems,**
  - ✓ **Have significant negative effects on human health & the environment.**
- The most commonly encountered POPs are **organochlorine pesticides**, such as
  - ✓ **Dichlorodiphenyltrichloroethane (DDT),**
  - ✓ **Endosulfan,**
  - ✓ **Polychlorinated biphenyls (PCB: resistant to extreme temperature & pressure**. PCBs were used widely in **electrical equipment** like capacitors & transformers),
  - ✓ **Dioxins (toxic by-products produced when organic matter is burned), etc**.
- DDT was widely used a few decades ago as an effective pesticide & insecticide.
- It was later identified as POP, & its usage was phased out in almost all developed countries.
- **DDT is banned for agricultural use in India**; however, it continues to be used for **fumigation against mosquitoes (disease vector control)** in several places in India In India.

23.1.1. Regulation of Persistent Organic Pollutants Rules, 2018

- MoEF has notified the **'Regulation of Persistent Organic Pollutants Rules, in 2018** under the provisions of **Environment (Protection) Act, 1986**.
- The rules prohibits the manufacture, trade, use, import and export of seven chemicals, namely:
  1. **Chlordecone,**
  2. **Hexabromobiphenyl,**
  3. **Hexabromodiphenyl ether and HeptaBromodiphenyl Ether (Commercial octa-BDE),**
  4. **Tetrabromodiphenyl ether and Pentabromodiphenyl ether (Commercial penta-BDE),**
  5. **Pentachlorobenzene,**
  6. **Hexabromocyclododecane, and**
  7. **Hexachlorobutadiene.**
- The ratification process would enable India to access the **Global Environment Facility (GEF) financial resources**.

23.1.2. Chlorinated Hydrocarbons (Organochlorides / Perfluoro Chlorides)

- **CHCs are hydrocarbons** in which **one or more hydrogen atoms have been replaced by chlorine** E.g., **DDT (dichlorodiphenyltrichloroethane), endosulfan, chloroform, carbon tetrachloride**, etc.

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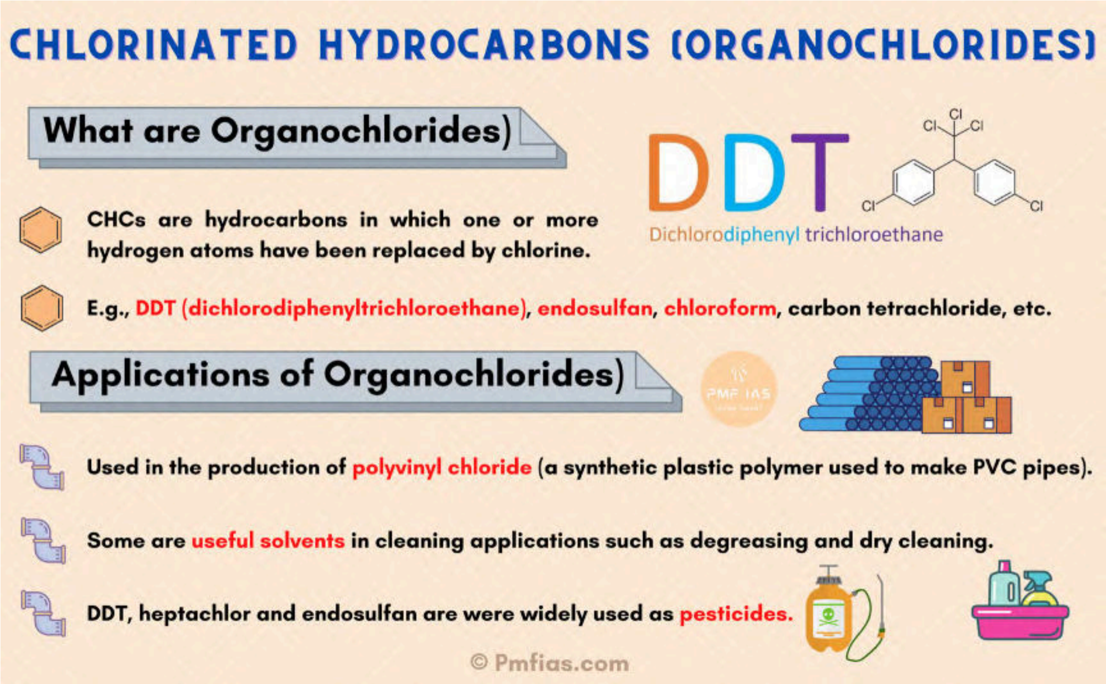

Applications of Chlorinated Hydrocarbons (CHC) / Perfluoro Chlorides

- CHCs are used in the production of **polyvinyl chloride** (synthetic plastic polymer used to make PVC pipes).
- **Chloroform, dichloromethane, dichloroethane,** & **trichloroethane** are useful **solvents**.
- These solvents are immiscible with water (not forming a homogeneous mixture when mixed with water) & effective in cleaning applications such as **degreasing & dry cleaning**.
- **DDT, heptachlor & endosulfan** were widely used as **pesticides**.

Effects of Chlorinated Hydrocarbons (CHC)

- DDT accumulated in food chains & caused **eggshell thinning in certain bird species**.
- In India, traces of DDT spray used three decades ago can still be found on the walls of homes.
- DDT residues continue to be found in mammals across the planet.
- In Arctic areas, particularly high levels are found in marine mammals.
- The traces of persistent organic pollutant are found in breast milk of several mammals.
- In females the concentration is lower due to transfer of the compounds to their offspring through lactation.

23.1.3. Perfluoroalkyl Acids (PFAAs)

- **Perfluoroalkyl acids (PFAAs)** are emerging **persistent organic pollutants**.
- They are used in water/stain-resistant coatings for clothing fabrics, leather, upholstery, and carpets and oil-resistant coatings for paper products approved for food contact, electroplating, electronic etching, etc.
- **They are different from Perfluoro Chlorides (organochlorines)**.
- PFAAs have a **long life** and are one of the major pollutants that **get stored in the glaciers**.
- They **do not biodegrade** and are passed through several organisms and ecosystems.
- Himalayan glaciers may have higher levels of PFAAs than any other glaciers in the world.
- This is because of their proximity to south **Asian countries** (most polluted regions of the world).
- The glaciers are releasing PFAAs into lakes and this can lead to bioaccumulation of PFAAs in fish.
- The consumption of contaminated fish can prove fatal for humans.

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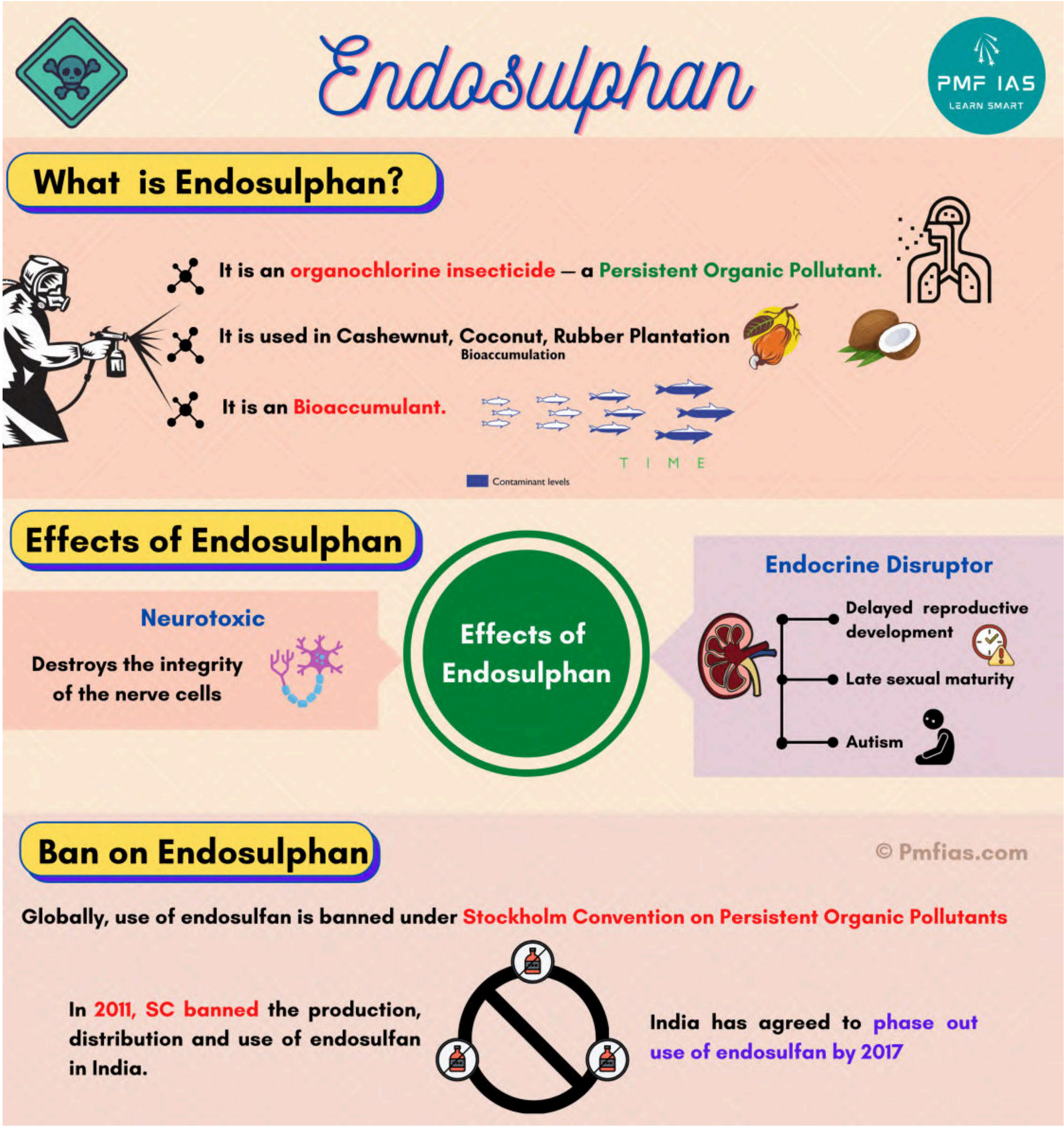
23.1.4. Endosulfan



- Endosulfan is an **organochlorine** insecticide — a **Persistent Organic Pollutant**.
- It is primarily used as an **insecticide** in agriculture & it is also used as a **wood preservative**.

Ban on Endosulfan

- India was one of the biggest producers & consumers of endosulfan.
- After the toxicity of the pesticide came into limelight in 2001 in Kasargod District, Kerala banned it.
- **In 2011, SC banned the production, distribution & use of endosulfan in India**.

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- SC also directed Kerala government to pay Rs 500 crores as compensation to over 5,000 victims.
- **Globally, use of endosulfan is banned under Stockholm Convention on Persistent Organic Pollutants**.
- Under pressure from pesticide firms **India sought remission on the ban for 10 years**.
- **India has agreed to phase out use of endosulfan by 2017**.

Hazardous Effects of Endosulfan

- It is **highly toxic** & has a large **potential for bioaccumulation (substance does not leave body)**.
- It has hazardous effects on **human genetic &** endocrine systems.
- **Endocrine disruptor: enhances the effect of estrogens causing reproductive & developmental damage** in both animals & humans.
  - ✓ Delayed reproductive development
  - ✓ Late sexual maturity
  - ✓ Autism
- **Neurotoxic:** endosulfan destroys the integrity of the nerve cells.

23.2. Laws, Conventions and Rules that Regulate Hazardous Waste

23.2.1. Stockholm Convention on Persistent Organic Pollutants

- **Stockholm Convention on Persistent Organic Pollutants** is an international environmental treaty.
- It came into effective in 2004.
- It aims to **eliminate or restrict the production & use of persistent organic pollutants (POPs)**.

Important Listed substances

- **Aldrin:** Used as an insecticide
- **Heptachlor:** Uses as a **termiticide** (including in the structure of houses and underground), for organic treatment and in underground cable boxes
- **Hexachlorobenzene:** Use as a chemical intermediate and a solvent for pesticides.
- **Endrin:** Endrin has been used primarily as an agricultural insecticide on tobacco, apple trees, cotton, sugar cane, rice, cereal, and grains.
- **Polychlorinated biphenyl:** PCB's commercial utility was based largely on their chemical stability, including low flammability, and physical properties, including electrical insulating properties. They are highly toxic.
- **DDT:** DDT is the best-known of several chlorine-containing pesticides used in the 1940s and 1950s.

23.2.2. Basel Convention

- **Basel Convention** on the **Control of Transboundary Movements of Hazardous Wastes** and **Their Disposal**.
- It **does not** address the movement of **radioactive waste**.
- Basel Convention entered into force in 1992.
- As of 2018, 186 states and the EU are parties to the Convention.
- **United States** has signed the Convention but has **not ratified it**.
- Basel Convention is an international treaty that was designed to:
  - ✓ **Reduce the movements of hazardous waste between nations**.
  - ✓ **Prevent the transfer of hazardous waste from developed to less developed countries (LDCs)**.
- The Convention is also intended to
  - ✓ Minimize the amount and toxicity of wastes generated, and
  - ✓ Assist LDCs in environmentally sound management of the hazardous and other wastes they generate.

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Shortcomings of Basel Convention: Toxic colonialism in the name of recycling

- Basel Convention focuses on **merely regulating the trade** in hazardous waste & **not in its complete ban**.
- It **does not prohibit waste exports** to any location **except Antarctica** but **merely requires a notification and consent** system known as "**prior informed consent**" or PIC.
- Many waste traders ship hazardous waste in the guise of moving the waste to recycling destinations.
- The recycling involves stripping of electronic waste, shipbreaking, etc. by desperate, unprotected workers.
- Further, wastes from the shipping companies — old ships, hazardous asbestos and flammable gases and oils — end up on beaches in **South Asia** where they create pollution and occupational diseases and hazards.
  - ⇨ ***Alang Ship Breaking Yard in Gujarat*** *is one of the biggest ship breaking yard in the world.*
  - ⇨ *In 2021 Budget speech, the Union Finance Minister spoke about* ***doubling the ship recycling capacity by 2024*** *and attracting more ships to India from Europe and Japan.*

Basel Ban Amendment to the Basel Convention

- Many believed a full ban on shipment of hazardous waste was needed including exports for recycling.
- This led to the adoption of an **amendment to the Basel Convention in 1995** termed the **Basel Ban Amendment**.
- Basel Ban Amendment required ratification by **3/4** of the parties to the Convention to become a law.
- It finally **became an international law** in September 2019 after Croatia ratified it.
- It will become a new Article in the Convention and will **enter into force in the 97 countries** after 90 days.
- However, countries like the US, Canada, Japan, Australia, New Zealand, South Korea, Russia, **India**, Brazil, and Mexico are **yet to ratify the ban**.
- The US produces the most waste per-capita but has actively opposed the Ban Amendment.
- The **Amendment prohibits the export of hazardous waste (including electronic wastes) from a list of developed (mostly OECD) countries to developing countries**.
- The Basel Ban **applies to export for any reason, including recycling**.
- The Basel Ban Amendment is hailed as a landmark agreement for **global environmental justice**.

Mains Practise: "There can be no excuse for using the developing world as the dumping ground for the toxic effluent of the affluent." Examine this statement in the light of Basel Ban Amendment. (250 Words)

23.2.3. Rotterdam Convention

- **Rotterdam Convention** on the **Prior Informed Consent Procedure** for **Certain Hazardous Chemicals and Pesticides in International Trade**.
- It is a multilateral treaty to promote **shared responsibilities** in relation to the importation of hazardous chemicals.
- The convention promotes an open exchange of information and calls on exporters of hazardous chemicals to use proper labelling, safe handling, and inform purchasers of any known restrictions or bans.
- Signatory nations can decide whether to allow or ban the importation of chemicals listed in the treaty.

23.2.4. Joint meetings of Basel, Rotterdam, and Stockholm Conventions

- The joint meetings of the three **conventions on chemicals and waste** were held in **Geneva** during Jan-Feb 2021.
  1. COP14 to Basel Convention
  2. COP9 to Rotterdam Convention
  3. COP9 to Stockholm Convention
- The theme of the meetings was "**Clean Planet, Healthy People: Sound Management of Chemicals and Waste**".

COP14 to Basel Convention

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- Amended the convention to **include plastic waste** in a **legally-binding framework**.
- The new amendment would empower developing countries to **refuse "dumping plastic waste"** by others (plastic waste included in the PIC (Prior Informed Consent) procedure).
- Even though the **U.S. and a few others have not signed the accord**, **they cannot ship plastic waste to countries that are on board with the deal**.
- **India** has already imposed a **complete prohibition** of import of solid plastic waste into the country.
- India has also made an international commitment to phase-out single-use plastic.

COP9 to Stockholm Convention

- Under the Stockholm Convention the COP decided to list "**Dicofol**" in Annex A without any exemption.
- The "**PFOA**" was also listed with some exemptions in the Annex A of the Stockholm Convention.

Dicofol

- **Dicofol is an organochlorine pesticide** that is chemically related to **DDT**.
- It has been used in a wide variety of industrial and domestic applications including **non-stick cookware** and food processing equipment, as well as carpets, paper and paints.

Perfluorooctanoic acid (PFOA)

- **Perfluorooctanoic acid (PFOA)** is used in the process of making **Teflon (used in non-stick cookware)**.
- PFOA can stay in the environment and in the human body for long periods of time.
- PFOA is a carcinogen, a liver toxicant, a developmental toxicant, and an immune system toxicant.

COP9 to Rotterdam Convention

- Under the Rotterdam Convention, two new chemicals (**acetochlor, hexabromocyclododecane (HBCD) and phorate**) were added in the list for mandatory PIC (Prior Informed Consent) procedure in international trade.

23.2.5. Hong Kong Convention

- The **Hong Kong International Convention** for the **Safe and Environmentally Sound Recycling of Ships, 2009 (the Hong Kong Convention).**
- It was developed in co-operation with the **International Labour Organization** and the Parties to the **Basel Convention**.
- The Hong Kong Convention intends to address all the issues around ship recycling, including the fact that ships sold for scrapping may contain hazardous substances such as asbestos, heavy metals etc.
- It also addresses concerns raised about the **working and environmental conditions** at many of the world's ship recycling locations.

23.2.6. Recycling of Ships Bill

- The Parliament has passed "The Recycling of Ships Bill 2019."
- The bill seeks to ensure **Environmentally Sound Recycling of Ships** & adequate safety of the yard workers.
- The **Shipbreaking Code, 2013** & the provisions of the **Hong Kong Convention** are present in this Bill.

Ship recycling

- The Bill defines ship recycling as the dismantling of a ship at a facility to recover the components and materials for reuse and taking care of the hazardous material so produced.

Requirements for ships

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- Ships should **not use prohibited hazardous materials** as notified.
- The central government may exempt certain categories of ships from this requirement.
- These requirements will not apply to: (i) any warship and (ii) ships with internal volume less than 500 tonne

National Authority

- The National Authority will carry out periodic surveys to verify the prescribed requirements.
- The owner of every new ship must make an application to the National Authority to obtain a certificate on the inventory of hazardous materials.

Recycling facilities

- Ships will be recycled only in authorised recycling facilities.
- Each Ship Recycler must maintain adequate measures for emergency preparedness and safety and welfare of workers.

Recycling process

- A ship owner must first apply to the National Authority for a ready for recycling certificate.
- The Ship Recycler must prepare a **ship recycling plan** which should be approved by the Competent Authority.
- Each ship will be recycled after obtaining written permission from the Competent Authority.

Key Benefits of the bill

- Increased number of global ships entering Indian Shipyards for Recycling.
- Recycling of Ships will boost business & employment opportunities.
- It will raise the value of our Ships Recycling Yards located at **Alang in Gujarat**, **Mumbai Port, Kolkata Port & Azhikkal in Kerala**.
- **10% of country's Secondary steel needs** can be met in an eco-friendly manner from recycled ships.
- Ships Recycling facilities will become compliant to international standards.

23.2.7. Hazardous Wastes (Management and Handling) Rules, 2016

- For the first time, Rules have been made to distinguish between **Hazardous Waste & other wastes**.
- **Other wastes include:** Waste tyre, paper waste, **metal scrap**, **used electronic items**, etc. and are recognized as a **resource for recycling and reuse**.

Salient Features

- The ambit of the Rules has been expanded by **including 'Other Waste'**.
- Waste Management hierarchy in the **sequence of priority** of prevention, minimization, reuse, recycling, recovery, co-processing; and safe disposal has been incorporated.
- It encourages reduction of hazardous waste generation and encourage its recycling and reusing.
- It specifies strict guidelines related to the **import and export or even storage and transportation of hazardous wastes**.

Import & Effort of Hazardous Waste

- **No country can export to India hazardous waste for final disposal**.
- This means that **India only imports hazardous wastes in order to recycle**, reuse or for other utilisation.
- The rules specify the **procedure for importing and exporting** hazardous waste to and from India.

Treatment, Storage and Disposal Facility for Hazardous Wastes

- 2016 rules give a clear direction of how the facility for treatment, storage & disposal is to be established.

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- Permission from the **State Pollution Control Board** is required for the layout in this regard.

Packaging, Labelling and Transport of Hazardous and Other Wastes

- Extensive guidelines are provided **by Central Pollution Control Board** for the packaging and labelling.
- In case the waste is to be transported to a facility in a different state for its final disposal, a **'No Objection Certificate'** is required on the part of the sender from the State Pollution Control Board of both the states.

Amendment of 2019

- Amendment has been done keeping into consideration the "Ease of Doing Business" & boosting "Make in India" initiative by **simplifying the procedures under the Rules**, while at the same time upholding the principles of sustainable development & ensuring minimal impact on the environment.

Salient Features

- **Solid plastic waste has been prohibited from import into the country** including in Special Economic Zones (SEZ) and by Export Oriented Units (EOU).
- **Exporters of silk waste** have now been given **exemption** from requiring permission from MoEF.
- Electrical and electronic assemblies and components manufactured in and exported from India, if found defective can now be imported back into the country without obtaining permission from MoEF.
- Industries which do not require consent under Water (Prevention and Control of Pollution) Act 1974 and Air (Prevention and Control of Pollution) Act 1981, are now exempted from requiring authorization also under the Hazardous and Other Wastes Rules, 2016.

23.2.8. Rules for Disposal of Cigarette Butts

- **Cellulose acetate** is a major component (95%) of the cigarette butts along with **rayon**.
- In general, the **toxicity date is not available for cellulose acetate**.
- **Cellulose acetate will persist for a longer duration**.
- National Green Tribunal (NGT) has directed the Central Pollution Control Board (CPCB) to lay down guidelines pertaining to disposal of cigarette and beedi butts.
- While the Environment Ministry had said that **cigarette butts were not listed as hazardous**, the Health Ministry had maintained that they were **not biodegradable**.

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24. Electronic waste | E-WASTE

- The discarded and end-of-life electronic products ranging from computers, equipment, home appliances, audio and video products and all of their peripherals are popularly known as electronic waste (E-waste).
- E-waste is **not hazardous if it is stocked in safe storage** or **recycled by scientific methods** or transported from one place to the other in parts or totality in the formal sector.
- The e-waste can, however, be considered hazardous if recycled by primitive methods.

24.1. Source and Health Effects

Particulars	Source	Health Effects
Lead	• Used in glass panels and gaskets in computer monitors • Solder in printed circuit boards and other Components	• Lead tends to accumulate in the environment and has high acute and chronic effects on plants, animals and microorganisms.
Cadmium	• Occurs in SMD chip resistors, infra-red detectors, and semiconductor chips • Some older cathode ray tubes contain cadmium	• Toxic cadmium compounds accumulate in the human body, especially the kidneys.
Mercury	• It is estimated that 22% of the yearly world consumption of mercury is used in **electrical and electronic equipment** • Mercury is used in thermostats, sensors, relays, switches, medical equipment, lamps, mobile phones and in batteries • Mercury, used in flat panel displays, will likely increase as their use replaces cathode ray tubes	• Mercury can cause damage to organs including the brain and kidneys, as well as the fetus. • The developing fetus is highly vulnerable to mercury exposure. • When inorganic mercury spreads out in the water, it is transformed to **methylated mercury** which **bio-accumulates** in living organisms and concentrates through the food chain, particularly via fish.
Hexavalent Chromium/ Chromium VI 29	• Chromium VI is used as **corrosion protector of untreated and galvanized steel plates** and as a decorative or hardener for steel housings Plastics (including PVC): **Dioxins** are released when PVC is burned. • The largest volume of plastics (26%) used in electronics has been PVC. PVC elements are found in cabling and computer housings. • Many computer mouldings are now made with the somewhat more benign ABS plastics	• Chromium VI can cause damage to DNA and is extremely toxic in the environment.
Barium	• Barium is used in computers in the front panel of a Cathode Ray Tube (CRT), to protect users from radiation	• Studies have shown that short-term exposure to barium causes brain swelling.
Beryllium	• Beryllium is commonly found on mother-	• Exposure to beryllium can cause lung cancer. • Beryllium also causes a skin disease that is

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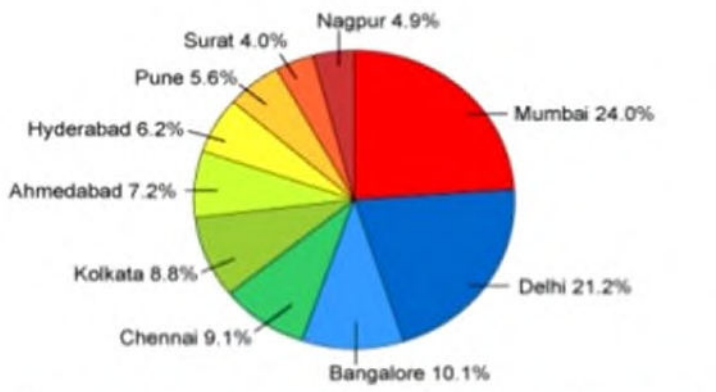
	boards and finger clips • It is used as a copper-beryllium alloy to strengthen connectors and tiny plugs while maintaining electrical conductivity	characterised by poor wound healing and wart-like bumps.
Toners	• Found in the plastic printer cartridge containing black and color toners.	• Inhalation is the primary exposure pathway, and acute exposure may lead to respiratory tract irritation. **Carbon black** has been classified as a class 2B carcinogen, possibly carcinogenic to humans.
Phosphor and additives	• Phosphor is an inorganic chemical compound that is applied as a coat on the interior of the CRT faceplate.	• The phosphor coating on cathode ray tubes contain heavy metals, such as **cadmium**, and other rare earth metals, for example, **zinc, vanadium** as additives. These metals and their compounds are very toxic.

24.2. E-Waste to Increase by 2030

- E–waste to increase 38% by 2030 according to United Nations University (UNU) report.
- Global e–waste will increase by 38 per cent in the decade between 2020 & 2030**.**
- There was 53.6 million tonnes (MT) e–waste in 2019, that is a nearly 21 per cent increase in just five years.
- **Asia generated the greatest volume of e–waste in 2019** — some 24.9 MT, followed by the Americas (13.1 MT) & Europe (12 MT).
- **Most E–waste in 2019 consisted of** small equipment(17.4 MT), large equipment (13.1 MT) & temperature exchange equipment (10.8 MT).
- Less than 18 per cent of the e–waste generated in 2019 was collected & recycled.
- E–waste consisting of **gold, silver, copper, platinum** & other high–value, recoverable materials worth at least $57 billion was mostly dumped or burned rather than being collected for treatment & reuse.

24.2.1. E-Waste in India

- India generates more 30 lakh metric tonnes (MT) of electronic waste every year, with Mumbai and Delhi-NCR accounting for the biggest chunk.
- Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur are other important cities generating a substantial amount of e-waste.
- Among the eight largest e-waste generating states, **Maharashtra** ranks first followed by **Tamil Nadu** (2nd), **Andhra Pradesh** (3rd), Uttar Pradesh (4th), Delhi (5th), Gujarat (6th), and Karnataka (7th).



City-wise E-waste Generation in India (Tonnes/year)

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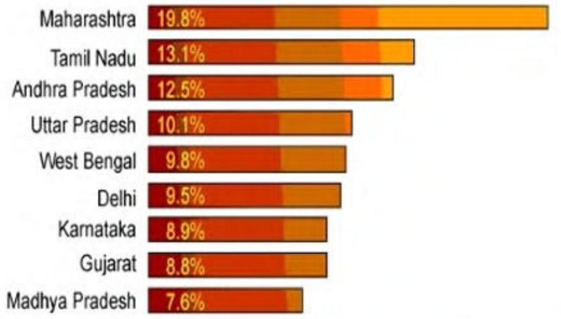

State-wise E-waste Generation in India (Tonnes/year)

- Over half of the e-waste generated in the developed world are exported to developing countries, mainly to **China, India and Pakistan**, where **copper, iron, silicon, nickel** and **gold** are recovered during recycling.
- Unlike developed countries, which have specifically built facilities for recycling of e-waste, recycling in developing countries often involves manual participation thus exposing workers to toxic substances.
- There are 300+ authorised recyclers of e–waste in India. However, formal recycling capacity remains underutilised, as the large majority of the waste is still handled by the **informal sector (more than 90%)**.

24.3. Heavy Metal Toxicity & Methods of Their Prevention

- Toxic metals are dispersed in the environment through metal smelting industrial emissions, burning of organic wastes, automobiles and coal-based power generation.
- Heavy metals can be carried to places far away from their source of origin by winds when they are emitted in gaseous form or form of fine particulates.
- Rain ultimately washes the air having metallic pollutants and brings them to the land and to water bodies.
- Heavy metals cannot be destroyed by biological degradation.
- The heavy metals often encountered in the environment include **lead, mercury, arsenic, chromium**. These are known to cause toxic effects in living organisms.

24.3.1. Lead

- Lead is a common pollutant that can get into the environment from a number of commonly used materials like **paints, cosmetics, batteries, glass** & **toys**.
- By 2011, the UN announced that it has been successful in **phasing out leaded gasoline worldwide**.
- **Battery scrap** also contains lead. It can get mixed up with water and food and create cumulative poisoning.
- India banned leaded petrol in 2000.
- The role of lead as a factor in the development of **neuro-degenerative diseases** has been well established.
- Exposure to this toxic heavy metal is associated with many dysfunctions of the central nervous system.
- Recent studies have established a possible link between lead exposure and Alzheimer’s disease.
- **Alzheimer's** is the most common cause of **dementia (memory loss)** and loss of other cognitive abilities (metal abilities closely associated with learning and problem solving).
- Maternal exposure to lead during pregnancy can cause developmental reprogramming which can lead to higher risk and early onset of Alzheimer’s disease in later life.
- Lead can cause irreversible behavioural disturbances, neurological damage and other developmental problems in young children and babies. It is a carcinogen of the lungs and kidneys.

What causes Lead Poisoning?

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- The informal recycling of **lead-acid batteries** is a leading contributor to lead poisoning in children living in low & middle-income countries. 50 per cent of lead-acid batteries are being unsafely recycled in the informal economy.

Other sources

- Lead exposure include lead in water from the use of **leaded pipes**.
- Lead from active industry, such as mining & battery recycling.
- Lead-based **paint & pigments**.
- Leaded gasoline, which has declined considerably in recent decades.
- Lead solder in food cans.
- Lead in spices, cosmetics, ayurvedic medicines, toys & other consumer products.

24.3.2. Mercury

- In Japan, mass mercury poisoning (**Minamata disease**) was observed in the 1960s, caused by eating fish from Minamata Bay which was contaminated with **methyl mercury**.
- Mercury kills cells in the body and damages organs and thus impairs their functioning.
- Inhalation of mercury vapours is more dangerous than its ingestion.
- Chronic exposure causes lesions in the mouth and skin and neurological problems.
- Mercury thermometers used earlier are getting replaced by mercury-free thermometer.

24.3.3. Arsenic

- Arsenic is associated with **copper, iron and silver ores**.

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- Arsenic is also emitted from **fossil fuel burning**.
- **Liquid effluents** from **fertilizer plants** also contain arsenic.
- Groundwater contamination with arsenic is quite common in areas where it is present.
- Chronic arsenic poisoning causes melanosis and keratosis (dark spots on the upper chest, back and arms are known as melanosis. The next stage is keratosis in which palms become hard) and leads to loss of appetite, weight, diarrhoea, gastrointestinal disturbances and skin cancer.
- Surface waters are generally free from arsenic pollution and should be preferred for drinking and cooking.

24.3.4. Cadmium

- Mining, especially of zinc and metallurgical operations, electroplating industries, etc., release cadmium in the environment.
- It may enter the human body by inhalation or from aquatic sources including fish, etc.
- It may cause hypertension, liver cirrhosis, brittle bones, kidney damage and lung cancer.
- **Itai-itai disease** first reported from Japan in 1965 was attributed to cadmium contamination in water and rice caused by the discharge of effluents from a zinc smelter into a river.

24.3.5. Other Heavy Metals

- Metals such as **zinc, chromium, antimony** and **tin** enter food from cheap cooking utensils.
- Preserved foods stored in tin cans also cause contamination by tin.
- Zinc is a skin irritant and affects the pulmonary system.

Q. Due to improper/indiscriminate disposal of old and used computers or their parts, which of the following are released into the environment as e-waste?

1. Beryllium
2. Cadmium
3. Chromium
4. Heptachlor
5. Mercury
6. Lead
7. Plutonium

Select the correct answer using the codes given below.

a) 1, 3, 4, 6 and 7 only
b) 1, 2, 3, 5 and 6 only
c) 2, 4, 5 and 7 only
d) 1, 2, 3, 4, 5, 6 and 7

Explanation:

- **Heptachlor** is a **Chlorohydrocarbon (CHC)** which is used as an insecticide.
- **Plutonium is a radioactive metal** and hence not used in computers.
- So, the answer should not contain either 4) or 7).

Answer: b) 1, 2, 3, 5 and 6 only

24.4. E-Waste Management Rules, 2016

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- The government passed the first law on **e-waste management in 2011**, based on **Extended Producer Responsibility (EPR),** which put the onus on the producer for the management of the final stages of the life of its product, in an eco-friendly way, by creating certain norms in tandem with state pollution control boards.
- **E-Waste Rules 2016 replaced 2011 Rules.**

Q. In India, 'extended producer responsibility' was introduced as an important feature in which of the following?

a) The Bio-medical Waste (management and handling) rules,1998
b) The Recycled Plastic (manufacturing and usage) rules, 1999
c) The e-Waste (Management and handling) rules, 2011
d) The food safety and standard regulations, 2011

Answer: c) e-waste

Salient Features

- Manufacturer, dealer, refurbishes & **Producer Responsibility Organization (PRO)** have been introduced as additional stakeholders in the rules.
- A new arrangement entitled, **Producer Responsibility Organisation (PRO)** has been introduced to strengthen EPR further.
- PRO, a professional organisation, would be authorised or financed collectively or individually by producers, **to share the responsibility for collection and channelisation** of e-waste generated from the '**end-of-life'** products to ensure environmentally sound management of such e-waste.
- Option has been given for setting up of **e-waste exchange, e-retailer, Deposit Refund Scheme** as additional channel for implementation of EPR by Producers to ensure efficient channelization of e - waste.
- **Deposit Refund Scheme** has been introduced as an additional economic instrument wherein the producer charges an additional amount as a deposit at the time of sale of the electrical and electronic equipment and returns it to the consumer along with interest when the end-of-life electrical and electronic equipment is returned.
- The e-waste exchange as an option has been provided in the rules as an independent market instrument offering assistance or independent electronic systems offering services for sale and purchase of e-waste generated from end-of-life electrical and electronic equipment between agencies or organizations.
- **Compact Fluorescent Lamp (CFL)** & **mercury containing lamp** brought under the purview of rules.
- Over **21 products (Schedule-I) were included** under the purview of the rule.
- The rule also extended its purview to components or consumables or parts or spares of **Electrical and Electronic Equipment (EEE),** along with their products.
- The rule has provisioned the **target for the producers**, which was missing in the first version of the Rule. Now, manufacturers are mandated to take back their sold products with recommended mechanisms.
- The manufacturer is also now responsible to collect e-waste generated **during the manufacture of any electrical and electronic equipment** and channelize it for recycling or disposal and seek authorization from **SPCB**.
- **Central Pollution Control Board (CPCB)** shall conduct **random sampling** of electrical and electronic equipment placed on the market to monitor and verify the compliance of law on **Restriction of Hazardous Substances (RoHS)** and the cost for sample and testing shall be **borne by the producer.**
- **Liability for damages** caused to the environment or third party due to improper management of e-waste including provision for levying financial penalty for violation of provisions of the Rules has also been introduced.

Amendment in 2019

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- The amendment in rules has been done with the objective of **channelizing the E-waste** generated in the country **towards authorized dismantlers & recyclers** to **formalize the e-waste recycling sector**.
- The collection targets under the provision of Extended Producer Responsibility (EPR) in the Rules have been revised and targets have been introduced for new producers who have started their sales operations recently.

Salient Features

- The **phase-wise collection targets for e-waste** in weight shall be 10% of the quantity of waste generation as indicated in the EPR Plan during 2017-18, with a 10% increase every year until 2023.
- After 2023 onwards, the target has been made **70% of the quantity of waste generation** as indicated in the EPR Plan.
- Separate e-waste collection targets have been drafted for new producers, i.e., those producers whose number of years of sales operation is less than the average lives of their products.
- The average lives of the products will be as per the guidelines issued by CPCB from time to time.
- Producer Responsibility Organizations (PROs) shall apply to the Central Pollution Control board (CPCB) for registration to undertake activities prescribed in the Rules.
- Under the Reduction of Hazardous Substances (RoHS) provisions, **cost for sampling and testing shall be borne by the government** for conducting the RoHS test.
- If the product does not comply with RoHS provisions, **then the cost of the test will be borne by the Producers**.

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25. Land Degradation

- Soil degradation is the decline in soil quality caused by its improper use, usually for agricultural, pastoral, industrial or urban purposes.
- Soil degradation is a serious global environmental problem and may be exacerbated by climate change.
- It encompasses physical (soil erosion), chemical (salinity and alkalinity, pollution) and biological deterioration (pollution and deterioration of vegetal cover).

25.1. Major Causes for Land Degradation

25.1.1. Deforestation

- The population explosion has created pressure on forest land and resources, and this causes deforestation.
- Deforestation **accentuates soil erosion (soil degradation)**.
- Roots of trees and plants bind the soil particles and regulate the flow of water, thus saving soil from erosion. Deforestation makes soil vulnerable to wind and water erosion.
- The large-scale damage to the soil in **Shiwalik range**, the **Chos of Punjab**, the **ravines of Chambal valley** are due to deforestation.

Major Causes of Deforestation

Shifting cultivation

- In this practice a patch of land is cleared, vegetation is burned, and the ash is mixed with the soil thus adding nutrients to the soil.
- This patch of land is used for raising crops for two to three years, and the yield is modest.
- Then this area is abandoned and is left to recover its fertility, and the same practice is repeated elsewhere on a fresh piece of land.
- This agricultural practice has become unsustainable due to rapid increase in population pressure in the forested areas.

Development project and Mining

- Opencast mining has resulted in deforestation all over the world.

Plantation Boom

- Increase in demand for cocoa, coffee, tea, sugar, palm oil, rubber etc. have resulted in deforestation in the tropical rainforests.

Raw Materials

- Wood is used as a raw material by various industries for making paper, plywood, furniture, match sticks, boxes, crates, packing cases, etc.
- Industries also obtain their raw materials from plants such as drugs, scents and perfumes, resin, gums, waxes, turpentine, latex and rubber, tannis, alkaloids, bees wax.

Other Causes

- Deforestation also results from overgrazing, agriculture, mining, urbanisation, flood, fire, pest, diseases, defence and communication activities.

Effects of Deforestation

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- Closed forests (based on canopy level) have diminished due to deforestation leading to an increase in **degraded forests**. Forests recycle moisture (natural motors) from soil into their immediate atmosphere by transpiration where it again precipitates as rain.
- Deforestation results in an **immediate lowering of groundwater level** (low percolation due to the quick surface runoff on barren lands) and in long-term reduction of precipitation.
- Due to deforestation, this natural reuse cycle is broken, and water is lost through rapid runoff.
- Deforestation affects the biota and neighbouring ecosystems, soil erosion, land degradation, alteration of groundwater channels, pollution and scarce.

25.1.2. Overgrazing

- During the rainy season, there is plenty of vegetation and animals get enough fodder.
- But during the dry period, there is a shortage of fodder, and the grass is grazed to the ground and torn out by the roots by animals.
- This leads to lose structure of the soil and the soil is easily washed away by rains.
- Moreover, the soil is pulverised (reduce to fine particles) by the hoofs of animals and thus proves detrimental to topsoil when heavy showers fall on it.
- Soil erosion due to overgrazing is a common site in the hilly areas.

25.1.3. Faulty Methods of Agriculture

- Much of the soil erosion in India is caused by faulty methods of agriculture.
- Wrong ploughing, lack of crop rotation and practice of shifting cultivation are the most adversely affecting methods of agriculture.
- If the fields are ploughed along the slope, there is no obstruction to the flow of water and the water washes away the topsoil easily.
- In some parts of the country, the same crop is grown year after year which spoils the chemical balance of the soil. This **soil is exhausted and is easily eroded by wind or water**.
- The removal of the forest cover shifting cultivation leads to the exposure of the soil to rains and sun which results in heavy loss of topsoil, especially on the hill slopes.

25.1.4. Soil Salinity and Soil Alkalinity

- In Saline and Alkaline Soils, the topsoil is **impregnated** (soak or saturate with a substance) with **saline and alkaline efflorescences** (become covered with salt particles).
- Undecomposed rock fragments, on weathering, give rise to **sodium, magnesium and calcium salts and sulphurous acid.**
- Some of the salts are transported in solution by the rivers.
- In regions with **low water table** (due to over irrigation in canal irrigated areas), the **salts percolate into the subsoil**, and in regions with good drainage, the salts are wasted away by flowing water.
- But in places where the drainage system is poor, the water with high salt concentration becomes stagnant and **deposits all the salts in the topsoil once the water evaporates**.
- In regions with the high sub-soil water table, injurious salts are transferred from below by the **capillary action** because of evaporation in the dry season.
- In **canal irrigated areas** plenty of the water is available, and the farmers indulge in **over irrigation** of their fields.
- Under such conditions, the **groundwater level rises** and **saline and alkaline efflorescences** consisting of salts of **sodium, calcium and magnesium** appear on the surface as a layer of white salt.

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- Vast tracts of canal irrigated areas in Uttar Pradesh, Punjab and Haryana; arid regions of Rajasthan, semi-arid areas of Maharashtra, Gujarat, Andhra Pradesh, Telangana and Karnataka etc. are facing this problem.
- Although Indira Gandhi canal in Rajasthan has turned the sandy desert into a granary, it has given birth to serious problems of salinity and alkalinity.

Q. Which of the following is/are the possible consequence/s of heavy sand mining in riverbeds? (2018)

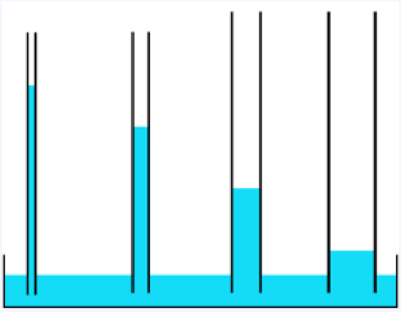
1) Decreased salinity in the river
2) Pollution of groundwater
3) Lowering of the water-table

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1 ,2 and 3

Explanation:

- Water accumulates in the (pores) space between soil particles and can stay in these spaces' dues to **capillary action**.
- Capillary action occurs because water is sticky and helps the water in pores overcome gravity.
- It is because of the **capillary action** that water (water table) is available just a few feet below the topsoil.



- When the soil is removed the capillary action is lost and the water table falls.
- In places of high-water table (near marshlands, wetlands, river beds) when the top soil is removed the water table is exposed to sunlight and evaporation increases salinity.
- Also, soil acts as a filter and when it is removed the pollutants manage to reach the ground water more easily.

Answer: b) 2 and 3 only

Effects of salinity and alkalinity

- Salinity and alkalinity have an adverse effect on soil and reduce soil fertility.
- Cultivation is not possible on saline soils unless they are flushed out with large quantities of irrigation water to leach out the salts.
- Choice of crops is limited to salinity-tolerant crops like cotton, barley etc.
- Quality of fodder and food produced is of poor quality.
- Salinity and alkalinity create **difficulties in building and road construction**.
- These cause floods due to reduced percolation of water.

Steps to treat salinity and alkalinity

- Providing outlets for lands to drain out excess water and lower water table.

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- Seal leakages from canals, tanks and other water bodies by lining them.
- Making judicious use of irrigation facilities.
- Improve vegetal cover to avoid further degradation by planting salt-tolerant vegetation.
- Crop rotation.
- **Liberal application of gypsum to convert the alkalis into soluble compounds**.
- Alkali (base) can be removed by adding sulphuric acid or acid forming substances like **sulphur and pyrite**.
- Organic residues such as rice husks and rice straw can be added to promote the formation of **mild acid** as a result of their decomposition.

25.1.5. Desertification

- Desertification is the spread of desert-like conditions in arid or semi-arid areas due to man's influence or climatic change.
- A large part of the arid and semi-arid region lying between the Indus and the **Aravalli range** is affected by spreading desert conditions.
- Desert soils suffer **maximum erosion by wind**. The sand carried by wind is deposited on the adjoining fertile lands whose fertility dwindles, and slowly the fertile land starts merging with the advancing desert.
- It has been estimated that the **Thar Desert is advancing** at an alarming rate of about 0.5 km per year.
- The process of desertification is attributed to uncontrolled grazing, reckless felling of trees and growing population. Climate change has also contributed to the spread of deserts.

Ecological implications of desertification

- Drifting of sand and its accumulation on fertile agricultural land.
- Excessive soil erosion by wind and to some extent by water.
- Deposition of sand in rivers, lakes decrease their water containing capacity.
- Lowering of water table leading to acute water shortage.
- Increase in area under wastelands.
- Decrease in agricultural production.
- Increase in frequency and intensity of droughts.

Measures for Controlling Desertification

- Intensive tree plantation in the transition zones.
- **Mulching shifting sand dunes** in deserts with different plant species. Mulches serve as an effective physical barrier to the moving sand.
- Grazing should be controlled, and new pastures should be developed.
- Indiscriminate felling of trees should be banned.
- Alternative sources of fuel can reduce the demand for fuelwood.
- Sandy and wastelands should be put to proper use by judicious planning.

25.1.6. Waterlogging

- The flat surfaces and depressions result in waterlogging.
- Waterlogged soils are soaked with water accumulated during the rainy season or due to leakage from various water sources.
- The extent of waterlogged soils is about 12 million hectares in India – half of which lies along the coast and the other half in the inland area.

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- Waterlogging is believed to be one of the **chief causes of salinity**.
- Proper layout of drainage schemes is the only way to overcome the menace of waterlogging.
- The basic methods of removing excess water from waterlogged soils are (a) surface drainage and (b) vertical drainage.
  (a) Surface Drainage: Surface drainage involves the disposal of excess water over ground surface through an open drainage system with an adequate outlet.
  (b) Vertical Drainage: Any bore or well from which the underlying water is extractedis defined as vertical drainage. It works well in Indo-Gangetic plain where the pumped water is used for irrigating the neighbouring regions.

25.1.7. Water Erosion

- Running water is one of the main agents, which carries away soil particles.
- Soil erosion by water occurs by means of raindrops, waves or ice.
- Erosion by water is termed differently according to the intensity and nature of erosion: **raindrop erosion, sheet erosion, rill and gully erosion, stream bank erosion, landslides, coastal erosion, glacial erosion**.

Raindrop erosion or Splash Erosion

- A raindrop is approximately 5 mm in diameter and hits the soil at a velocity of 32 km/hr.
- Raindrops behave like tiny bombs when falling on exposed soil, displace soil particles and destroy soil structure.
- Presence of vegetation on land prevents raindrops from falling directly on the soil thus erosion of soil in areas covered by vegetation is prevented.

Sheet erosion

- With continued rainfall the displaced soil particles fill in the spaces between soil particles and **prevent water from seeping into the soil**. This results in **surface runoff** and even more erosion.
- The detachment and transportation of soil particles by flowing rainwater is called **sheet/wash off erosion**.
- Weathering and erosion tend to level down the irregularities of landforms and create a **peneplane**.

Rill and gully erosion

- In rill erosion finger like rills appear on the cultivated land after it has undergone sheet erosion.
- These rills are usually smoothened out every year while forming.
- Each year the rills slowly increase in number become wider and deeper.
- Gully erosion is the removal of soil along drainage lines by surface water runoff.
- When rills increase in size, they become gullies.
- Once started, gullies will continue to move by headward erosion or by slumping of the side walls.
- Gullies formed over a large area gives rise to **badland topography (Chambal Ravines)**.

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- When a gully bed is eroded further due to headward erosion, the bed gradually deepens and flattens out, and a **ravine** is formed. The depth of a ravine may extend to 30 metres or more.
- Further erosion of ravine beds gives rise to **canyons.** Canyons are few hundred meters deep and wide. E.g., **Grand Canyon on Colorado River**.

Streambank erosion

- The erosion of soil from the banks (shores) of the streams or rivers due to the flowing water is called bank erosion.
- In certain areas where the river changes its course, the river banks get eroded at a rapid rate.
- Streambank erosion damages the adjoining agricultural lands, highways and bridges.

Landslide

- The sudden mass movement of soil is called a landslide.
- Landslides occur due to instability or loss of balance of land mass with respect to gravity.
- The loss in balance occurred mainly due to excessive water or moisture in the earth mass.
- Gravity acts on such an unstable landmass and causes the large chunks of surface materials such as soil and rocks to slide down rapidly.

Coastal erosion

- In the coastal areas, waves dash along the coast and cause heavy damage to the soil.
- During the landfall of cyclones, storm surges destroy beaches and wash away the top layer.
- In estuaries, tidal bores cause extensive damage to the surrounding banks.

Groyne for coastal protection

- A groyne is a shore protection structure **built perpendicular to the shoreline** of the coast (or river), over the beach to reduce longshore drift and trap sediments.
- A **groyne** functions as a physical barrier by **intercepting sand moving along the shore.**
- Rock is often used as construction material, but wooden groynes, steel groynes, rubble-mound and sand-filled bag groynes, or groynes made of concrete elements can also be found.
- Rock groynes are generally preferred as they are more durable and absorb more wave energy due to their permeable nature.

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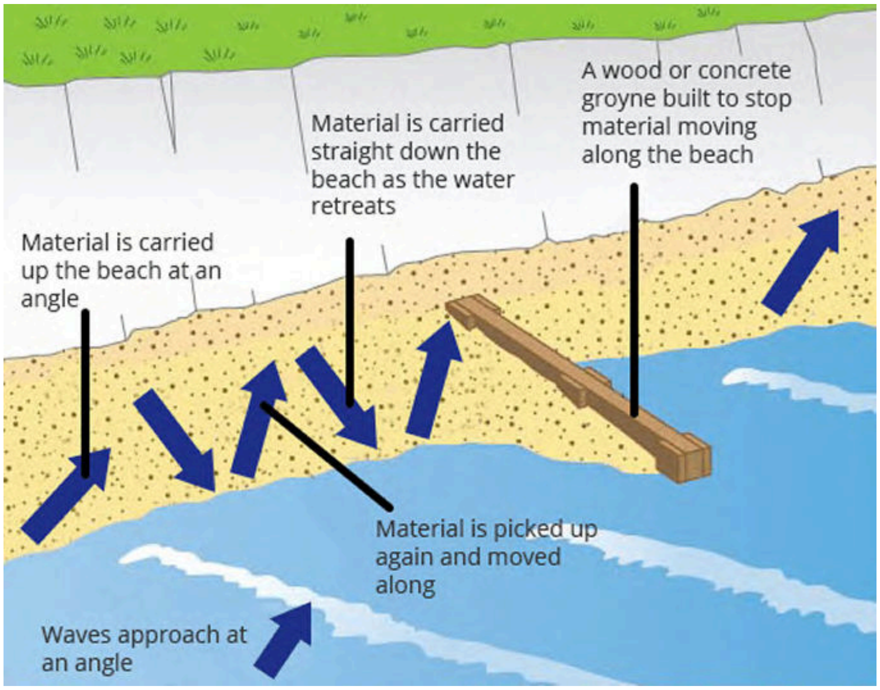

Glacial erosion

- In the polar regions and high mountainous regions like the Himalayas, soil erosion is caused by **slowly moving glaciers**. This is called glacial erosion.

25.1.8. Wind Erosion

- Wind erosion or **aeolian erosion** is quite significant in **arid and semi-arid regions**.
- Winds usually blow at high speeds in deserts due to the absence of physical obstruction.
- These winds remove the fertile, arable, loose soils leaving behind a depression devoid of topsoil.
- The depression formation in deserts is the first step in **Oasis formation**. Oasis forms in depressions when there is underground water that gets accumulated above rocks.
- Very fine and medium sands are moved by wind in a succession of bounds and leaps, known as **saltation**.
- Small sand and dust particles are transported over long distances through the air by a process known as **suspension**.
- Coarse sand is not usually airborne but rather is rolled along the soil surface. This type of erosion is called **surface creep.**
- Very coarse sand and gravels are too large to be rolled by wind, so wind-eroded soils have surfaces covered with coarse fragments. This kind of arid soil surface is known as **desert pavement**.

25.2. Addressing Land Degradation and Desertification

- **SDG 15: Life on land:** "promote sustainable use of terrestrial ecosystems, sustainably manage forests, **combat desertification**, and **halt and reverse land degradation** and halt biodiversity loss."
- The pace of desertification has accelerated 30 to 35 times the historical rate in the recent decades.
- At least one-quarter of the global land has degraded in the last two decades.
- Some 1,500 million people depend on this degrading land for their livelihood.

25.2.1. Soil Conservation

- With soil conservation people rise and with its destruction, they fall. Neglect of soil is like killing the hen that lays the golden egg.

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- Soil conservation is the **prevention of soil from erosion or reduced fertility caused by overuse, acidification, salinisation or other chemical soil contamination**.
- Soil erosion is the greatest single evil to Indian agriculture and animal husbandry.

Crop Rotation

- Adopting sustainable agricultural practices is the most important measure to conserve soil.
- In many parts of India, a particular crop is sown in the same field year after year. This practice leads to exhaustion of certain nutrients in the soil making it infertile.
- Crop rotation is a **practice in which a different crop is cultivated on a piece of land each year**.
- This helps to conserve soil fertility as different crops require different nutrients from the soil. Crop rotation will provide enough time to restore lost nutrients.
- For example, potatoes require much potash, but wheat requires nitrate. Thus, it is best to alternate crops in the field.
- Legumes such as peas, beans, and many other plants, add nitrates to the soil by converting free nitrogen in the air into nitrogenous nodules on their roots.
- Thus, if they are included in the crop rotation nitrogenous fertilisers can be dispensed with.

Strip Cropping

- **Crops may be cultivated in alternate strips, parallel to one another**. Some strips may be allowed to lie fallow while in other different crops may be sown.
- Various crops are harvested at different intervals. This ensures that at no time of the year the entire area is left bare or exposed.
- The tall growing crops act as windbreaks and the strips which are often parallel to the contours help in increasing water absorption by the soil by slowing down runoff.

Use of Early Maturing Varieties

- Early maturing varieties of crops take less time to mature and thus put lesser pressure on the soil. In this way, it can help in reducing the soil erosion.

Contour Ploughing

- If ploughing is **done at right angles to the hill slope**, the ridges and furrows break the flow of water down the hill.
- This prevents excessive soil loss as gullies are less likely to develop and also reduce run-off so that plants receive more water.

Checking Shifting Cultivation

- Checking and reducing shifting cultivation by persuading the tribal people to switch over to settled agriculture is a very effective method of soil conservation.
- This can be done by planning for their resettlement which involves the provision of residential accommodation, agricultural implements, seeds, manures, cattle and reclaimed land.

Ploughing the Land in Right Direction

- Ploughing the land in a direction perpendicular to wind direction also reduces wind velocity and protects the topsoil from erosion.

Mulching

- The **bare ground (topsoil) between plants is covered with a protective layer of organic matter** like grass clippings, straw, etc.

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Benefits

- Protects the soil from erosion.
- It helps to retain soil moisture.
- Reduces compaction from the impact of heavy rains.
- Conserves moisture, reducing the need for frequent watering.
- Maintains a more even soil temperature.
- Prevents weed growth.
- Organic mulches also improve the condition of the soil. As these mulches slowly decompose, they provide organic matter which helps keep the soil loose.

Contour barriers

- Stones, grass, soil are used to build barriers along contours.
- Trenches are made in front of the barriers to collect water.
- They intercept downslope flowing water and soil particles.
- These barriers slow down the water movement and reduce its erosive force.
- They also filter out and trap many of the suspended soil particles, keeping them from being washed out of the field.
- A long-term advantage of barriers is that soil tends to build up behind them, creating a terrace effect. Barriers can be classified as live (strips of living plants), dead (rocks, crop residues), or mixed (a combination of the previous two).

Rock Dam

- Rocks are piled up across a channel to slow down the flow of water. This prevents gullies and further soil loss.

Terrace farming

- In terracing, a number of terraces are cut along the hill slope.
- These are made on the steep slopes so that flat surfaces are available to grow crops. They can reduce surface run-off and soil erosion.

Fig 2.5: Terrace Farming

Fig 2.6: Contour Ploughing

Contour Bunding

- **Contour bunding involves the construction of banks along the contours**.
- **Terracing and contour bunding** which divide the hill slope into numerous small slopes, check the flow of water, promote absorption of water by soil and save soil from erosion.
- Retaining walls of terraces control the flow of water and help in reducing soil erosion.

Intercropping

- Different crops are grown in alternate rows and are sown at different times to protect the soil from rain wash.

Contour ploughing

- Ploughing parallel to the contours of a hill slope to form a natural barrier for water to flow down the slope

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Shelterbelts or Windbreaks

- In the coastal and dry regions, rows of trees are planted to check the wind movement to protect soil cover.

Sand fences

- Sand fences are barriers made of small, evenly spaced wooden slats or fabric.
- They are erected to reduce wind velocity and to trap blowing sand.
- Sand fences can be used as perimeter controls around open construction sites to keep sediments from being blown offsite by the wind.

Afforestation

- It includes the prevention of forest destruction along with growing new forests or increase area under forests.
- A minimum area 20 to 25 per cent of forest land was considered healthy for soil and water conservation for the whole country.
- It was raised to 33 per cent in the second five-year plan – 20 per cent for the plains and 60 per cent for hilly and mountainous regions.

Checking Overgrazing

- Overgrazing accentuates erosion. During the dry period, there is a shortage of fodder, and the grass is grazed to the ground and torn out to the roots by animals. The soil is pulverised (reduce to fine particles) by the hoofs of animals. All this leads to the weak top layer.
- So overgrazing needs to be checked to prevent soil erosion.
- This can be done by creating separate grazing grounds and producing larger quantities of fodder.

Dams

- Much of the soil erosion by river floods can be avoided by constructing dams across the rivers in proper places. This checks the speed of water and saves soil from erosion.
- But indiscriminate dam construction can worsen the condition by creating floods and landslides like it happens in the Himalayan region.

Geotextiles

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- **Geotextiles** are permeable synthetic/natural fabric used in association with soil to reinforce and protect it.
- Geotextiles are used to improve soils over which roads, embankments, & soil retaining structures are built.
- Synthetic geotextiles are typically made from **polypropylene** or polyester.
- Natural geotextiles are made from jute, coconut coir, etc.
- In 2020, GOI has allowed the use of coconut coir-based geotextiles for **construction of rural roads** under the Pradhan Mantri Gram Sadak Yojana.

Q. In rural road construction, the use of which of the following is preferred for ensuring environmental sustainability or to reduce carbon footprint? (2020)

1. Copper slag
2. Cold mix asphalt technology
3. Geotextiles
4. Hot mix asphalt technology
5. Portland cement

Select the correct answer using the code given below:

a) 1, 2 and 3 only
b) 2, 3 and 4 only
c) 4 and 5 only
d) 1 and 5 only

Explanation:

- **Hot mix asphalt involves liquefying coal tar by burning. 4) is eliminated**
- **Portland cement has higher limestone content (calcium carbonate). When limestone is heated in a cement or brick kiln it releases CO_2. 5) is eliminated ➔ a) is the answer**
- **Cold mix asphalt technology uses unheated mineral aggregate with foamed bitumen. It does not require any heating and is causes less pollution.**
- **Copper slag is a key by-product in the manufacturing process of copper, with very similar physical properties of conventional sand.**
- **Globally, the copper slag is used in cement manufacturing, cement concrete applications, bricks, etc..**

Answer: a) 1, 2 and 3 only

25.3. United Nations Convention to Combat Desertification (UNCCD)

- **UNCCD**, along with the **Convention on Biological Diversity** and the **UNFCCC**, emerged from the **1992 Rio de Janeiro Earth Summit**.
- Established in 1994, UNCCD is an agreement for ensuring **global action against land degradation**.
- It is the **only legally binding** international agreement that **links environment and development to sustainable land management**.
- UNCCD was adopted in Paris in 1994 and ratified by 196 countries & European Union.
- **India** ratified the UNCCD Convention in 1996.

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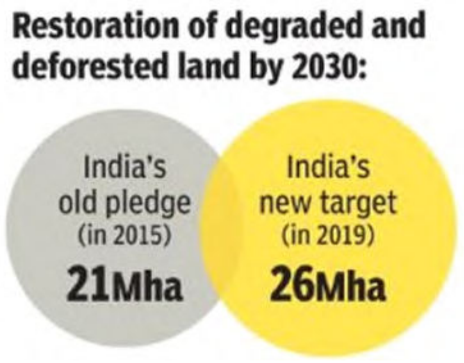
- The Convention requires countries to draw up their **national action programmes (NAP)** using a bottom-up approach — from the local community up — to restore degraded lands.
- The **Global Mechanism (GM)** was established under UNCCD to assist countries in the mobilization of financial resources to implement the Convention.

25.3.1. Land Degradation Neutrality (LDN) initiative

- The concept of LND emerged from the **UN Conference on Sustainable Development (Rio+20)** in 2012.
- In 2015, LDN became a target for the **SGD 15**, which is about sustaining life on land.
- **At COP12 to UNCCD, Parties adopted LDN** as a "strong vehicle for driving implementation of UNCCD" and called on countries to set voluntary targets to achieve **"no net loss" by 2030**.
- **New Delhi Declaration**: **190+ countries** agreed to achieve **'land degradation neutrality' by 2030** and vowed to ensure that the efforts in this direction **do not affect land rights** of **forest dwellers** and **women**.
- The countries will, however, must mobilise a huge sum of **$300 billion** to step up the restoration exercise.
- LDN initiative will generate multiple benefits, from climate change mitigation and adaptation to zero hunger: by ensuring access to clean water to creating decent work and green jobs.
- **India's LND Targets: India will restore 26 million hectares of degraded land by 2030; earlier the target was 21 mha**.



25.3.2. UNCCD CoP-14 in New Delhi

- The CoP is the supreme decision-making body of UNCCD. It is held every **two years**.
- The CoP reviews the implementation of the Convention, formulates strategies, coordinates its work with other agencies and NGOs, and so on.
- **New Delhi** hosted the 14th session of Conference of Parties (CoP-14) from 2 to 13 September 2019.
- India is among the select few countries to have hosted the COP of all three Rio conventions. At CoP14, India was elected **president** for the **next two years**.
- Representatives from over 197 countries, NGOs, etc. addressed the issue of **combating desertification,** land degradation & **drought** during the two-week event.
- "**Restore land, sustain future**" was the theme of COP14.
- The theme is centred around the wisdom that **land is a fixed resource**. If mistreated, its topsoil can be washed away in a few seasons, exacerbating food insecurity, poverty, migration and political instability.

Only 25% nations include gender discussions in land degradation targets

- The UNCCD recognised that in most developing countries, land degradation impacts men and women differently, mainly due to **unequal access to land**, water, credit, extension services and technology.
- The UNCCD had, for the first time, come up with a **Gender Action Plan (GAP)** in China in 2017.

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- Gender mainstreaming provides additional benefits to advance **gender equality**, increase women's access to and control over land and natural resources, reduce poverty, restore ecosystems, and so on.
- The UNCCD mandates **gender mainstreaming** in advancing the efforts of countries to achieve their Land Degradation Neutrality (LDN) targets.
- Only around 20/80 countries have included discussions on the role of gender and women in their targets to halt land degradation by 2030.

Report on Soil Organic Carbon

- The report is titled Realising the **Carbon Benefits of Sustainable Land Management Practices**.
- Soil Organic Carbon (SOC) is pivotal in providing multifaceted benefits.
- It combats droughts, reduces soil diseases and soil compacting and helps in organic production. Because of its multi-functional roles and its sensitivity to land management, **SOC is one of the three global indicators of Land Degradation Neutrality (LDN)**.

25.3.3. UNCCD Global Land Outlook Report

Loss of cropland due to urbanization

- Human settlements have historically developed in the most fertile areas, and on accessible lands.
- Their growing size is beginning to significantly displace fertile agricultural land.
- Urbanisation is projected to cause the loss of between 1.6 and 3.3 million hectares of prime **agricultural land** per year in the period between 2000 and 2030. (Between 48 and 99 million hectares in the period.)
- The loss of croplands translates into a 6 per cent production loss in Asia and a 9 per cent drop in Africa.

Biodiversity loss

- The biodiversity loss due to urbanisation by 2030 in Western Ghats and Sri Lanka hotspots could increase by approximately 900 per cent over their 2000 levels.

Increasing meat consumption across the world has put great pressure on land.

- Reducing the average meat consumption from 100 grams to 90 grams per person per day would make a significant impact on both, human health and **mitigation of climate change**.
- The growing demand for meat and other land-intensive food (processed food using soy and palm) had led to crises like **land scarcity** and **food insecurity**.

Water scarcity

- The demand for water is projected to outgrow extraction capacity by 40 per cent by 2030.
- By 2050, up to one billion urban dwellers could experience water shortages.
- Around two-thirds of the world's population would be living in water-stressed countries by 2025.
- Demand of water for agricultural purposes will double by 2050 due to growing demands for food.
- 20 per cent of irrigated land area had suffered from crop yield reductions due to **salinity**.
- The **most water-intensive crops** are:
    1. **cotton** (7,000 to 29,000 litres/kg),
    2. **rice** (3,000 to 5,000 litres/kg),
    3. **sugar cane** (1,500-3,000 litres/kg),
    4. **soya** (2,000 litres/kg) and
    5. **wheat** (900 litres/kg).
- At present, two billion people and 40 per cent of irrigation were dependent on **ground water**.

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- **India (39 million hectares)**, China (19 mha) and the US (17 mha) were intensively using ground water.

Drought

- There is a strong nexus between land use and drought and the management of both, land and drought, need to be fundamentally linked.
- Drought was one of the **five 'Strategic Objectives'** of the UNCCD for 2018-2030.
- **UNCCD introduced the concept of 'drought-smart land management' (D-SLM)** within the broader group of SLM (sustainable land management)-based interventions.

Cost

- An investment of $1.8 trillion in climate-adaptation measures over the next decade will bring about concrete transformation on the ground.
- Investment in five areas, including early warning systems, climate-resilient infrastructure, improved dryland agriculture and mangrove protection, **will give four times the return on investment** — $7.1 trillion.

Land for Energy Sources

- The report underscored how extraction of energy, from both fossil and renewable sources, needs land.
- Biomass is the most land-intensive energy source.
- Generating Solar power needs the most amount of land among green energy sources.
- **Concentration Solar Power System (CSP)** takes up 15 m^2 for every megawatt hour while coal takes five.

25.3.4. Desertification from Conservation Perspective

- By desertification, we do not mean the natural expansion of existing deserts in the world.
- When we say desertification, we mean the degradation of land in arid, semi-arid and dry sub-humid areas.
- It is a gradual loss of soil productivity — which makes raising of food grains and other crops impossible.
- When land degradation happens in drylands, it usually creates desert-like conditions.
- Desertification of this kind happens because of over-exploitation, droughts, and other climatic causes.

Importance of reversing land degradation

- Restoration of the degraded land in drylands is important. 34% of the earth's land surface and half of the farmlands are in these drylands.
- Over 2 billion people and half of the world's livestock live depend on these lands.

Effects of land degradation on people

- Vegetative cover vanishes from degraded land, making it uninhabitable for both humans and animals.
- Forced migration and sociocultural and religious conflicts over land and water are the telling effects.
- In many countries, land productivity loss has forced the exodus of people from villages to the cities.
- Forced migration causes brain drain on the country of origin.
- For the host countries, the migrants are a huge burden on their resources and social equations.

25.4. Desertification Setting in Across a Quarter Of India

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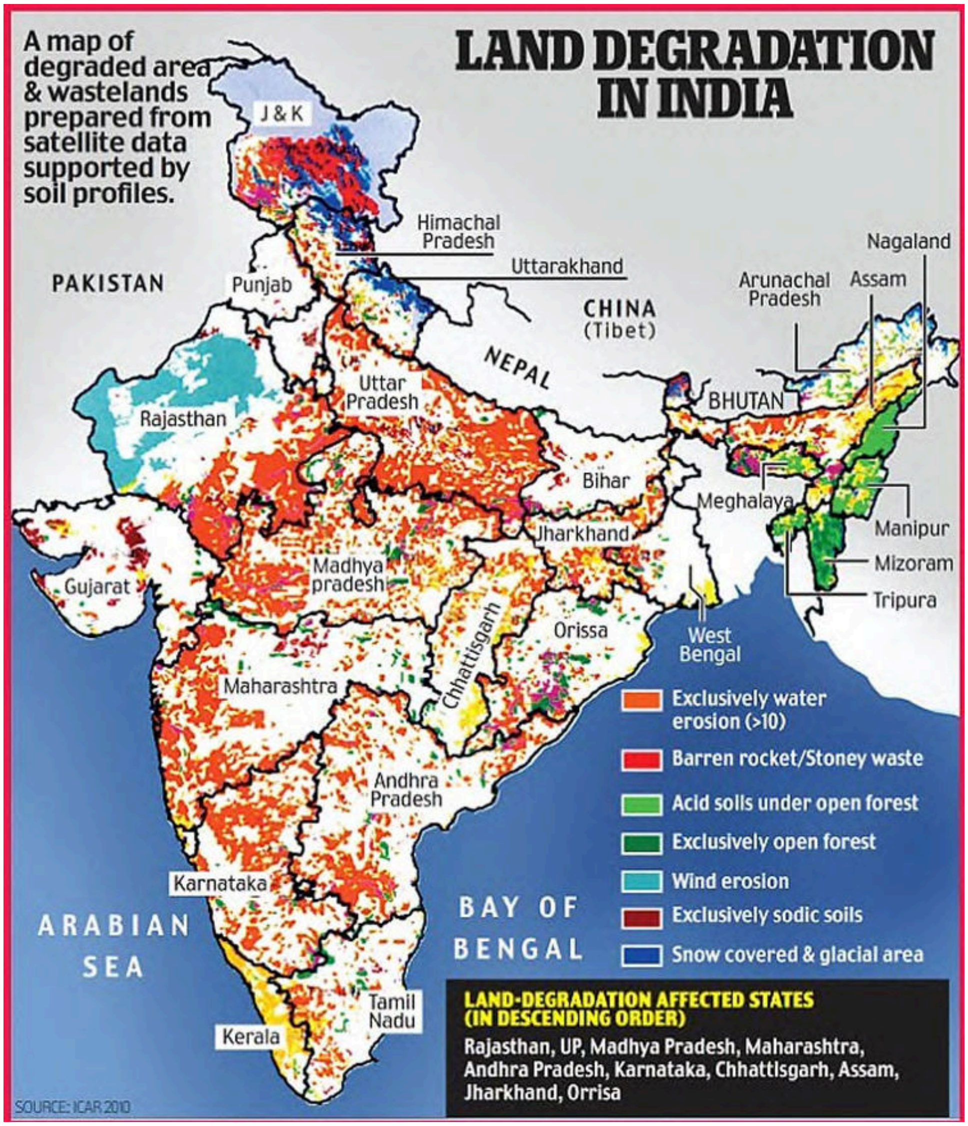

- According to **Desertification and Land Degradation of Selected Districts of India**, published by the **ISRO**, some **96.40 mha, or about 30 per cent** of the country's total area, is undergoing degradation.
- **Drylands** span **228.3 mha (70%)** of India's total land.
- **82.6 mha of drylands (~25% of total land area)** is under desertification.
- TERI's estimate shows land degradation costs $48.8 billion to the country's exchequer annually.
- This is almost 2.08 per cent of India's GDP in 2014-15.

25.4.1. Regional causes behind desertification and degradation

- **Maharashtra: timber mafia** is eating into already thin forests, leading to soil erosion.
- **Jharkhand & Odisha: Excessive mining** has triggered soil erosion and aggravated water scarcity.
- **Goa: Rampant mining** and expanding urbanisation have taken a toll.
- **Nagaland:** **shifting cultivation (jhum cultivation)** and rising population are to blame for desertification.
- Andhra Pradesh, Telangana & Hyderabad Karnataka: droughts and **increased dependence on borewells** have led to soil aridity.
- Himachal Pradesh: less snow and more rainfall has deepened the desertification crisis.
- Gujarat: **Overgrazing** and encroachment of grasslands for agricultural activities.

25.4.2. The case of Goa

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Deforestation due to illegal mining

- Unscientific and illegal mining in Goa has led to severe degradation, according to **ISRO's Land Degradation and Desertification Atlas published in 2018**.
- The rush to export iron ore from to China's 2008 Olympics building frenzy degraded large swaths of forests.
- SC had to stop mining in Goa in 2012 pointing to large scale illegal mining.

Soil degradation due to leeching of harmful chemicals

- When it rains the area around the mines becomes **red with lateritic soil**.
- To get a tonne of ore, 2.5 to 3 tonnes of overburden (soil) need to be extracted.
- This overburden is mostly dumped outside mine-leased area on agricultural land which leeches out.

Apathy in environmental governance

- **Most of Goa's forests are outside recorded forest areas**, according to FSI's 2017 State of Forest Report.
- The total forest cover in the state was recorded at 2,229 sq km or 60.21 per cent of the state.
- But state forest department, in its own records, has only 1,224.46 sq km as government forest.
- Take the example of **Mopa**, where the Goa government wants to build an airport. When the EIA for the airport was done **it showed no tree cover**.
- But when the court case was filed, the forest department found 54,676 trees!

25.4.3. Desertification in cold areas

- High altitude regions that get very little rainfall and are known as cold deserts.
- About 80 per cent of the cold desert region in India is in the union territory of Ladakh, while the rest is in Himachal Pradesh and Uttarakhand. There is clear evidence of desertification increasing in the trans-Himalayan regions in the form of **shifting tree lines**, migrating dunes and changes in soil moisture levels.

25.4.4. India lost 31% of grasslands and 19% of common lands in a decade

- The total area under **grasslands reduced 31% — 12.3 mha** from **18 mha** — between 2005 and 2015.
- Grasslands in the **Aravalli range** in Rajasthan underwent severe degradation.
- The country lost around 19 per cent of its common lands (90.5 mha to 73.02 mha) during the same period.
- Common lands include the grazing grounds, some forest land, ponds, rivers, and other areas that all members of a rural community can access and use.

25.4.5. State of India's Environment (SoE) Report 2019

- India has witnessed increase in the level of desertification in 26 of 29 states between 2003-05 and 2011-13.
- India had committed to achieve **land degradation neutrality by 2030**. But it witnessed an **increase of 1.87 million hectares** undergoing process of desertification between 2003-05 and 2011-13.
- More than 80 per cent of the country's degraded land lies in just nine states: **Rajasthan, Maharashtra, Gujarat, Jammu and Kashmir, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telangana**.
- Top three districts with highest area under desertification or land degradation are **Jaisalmer** (92.96 per cent during 2011-13), **Lahaul and Spiti** (80.54) and **Kargil** (78.23).

Q. The process of desertification does not have climatic boundaries. Justify with examples. (UPSC CSE Mains 2020 – 150 words).

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25.5. Bonn Challenge

- The **Bonn Challenge**, launched in 2011, aims to bring **150 mha of the world's deforested and degraded land into restoration by 2020**.
- In 2014, at the UN Climate Summit, countries extended this target to **350 mha by 2030** under the **New York Declaration on Forests**.
- At the UNFCCC 2015 in Paris, India joined the **voluntary** Bonn Challenge pledge to bring into restoration
  - ✓ **13 million hectares of degraded and deforested land by the year 2020, and**
  - ✓ **additional 8 million hectares by 2030. (It was later increased to 13 mha)**

25.5.1. India and Bonn Challenge, Paris Agreement

- At the current rate of afforestation, only **35 million tonnes of CO_2 equivalent** a year can be sequestered. This is way less than India's commitment under the Paris Agreement to increase carbon sequestration through forests by **2.5-3 billion tonnes of CO_2 by 2030**.
- Right now, **70.87 mha, or 24.39** per cent of the country, is under forest cover.
- To meet Paris Agreement and Bonn Challenge, an **additional 25-30 mha** needs to be brought under it.
- That is, **at least one-third of the total land area of the country must come under forest and tree cover**.

25.5.2. Meeting targets through Compensatory Afforestation

Compensatory Afforestation Fund (CAF) Act, 2017

- To make up for the loss of forests cleared for non-forest projects (industries, infrastructure), the CAF allows **afforestation on an equal size of revenue land** elsewhere.
- Until 2019, afforestation **was allowed on degraded forest land only if revenue land was not available**.
- In that case, the **degraded land will be twice the size of the forestland diverted**.
- MoEFCC brought in a notification under CAF, **allowing compensatory afforestation in forestland where crown density is less than 40 per cent**.

Challenges

- Forests with crown density between 40 and 10 per cent are classified as as "**open forest**".
- Open forest is **second-largest category** in the country, spanning over **30 mha**. This is 9.18 per cent of India's landmass or 42 per cent of the forest cover.
- Opening up of this huge area for plantation works opens a Pandora's box of **land tenure conflicts**.
- The country has some 300 million people who traditionally live in and around forests.
- FRA act recognises their rights over forestland. **Each of them is eligible for at least 4 ha**.

Increasing tree cover outside forest areas

- In 2018, MoEFCC released the **Strategy for Increasing Green Cover Outside Recorded Forest Areas**, which says **wasteland, fallow land and other degraded lands** should be the focus area of afforestation.
- The country has some 10 mha of culturable waste land.
- MoEF is trying to empower people and institutions through monetary incentives & flexible rules so that these areas can be brought under plantations.

Challenges

- Trees provide a good soil cover only at places where rainfall is above 50 or 60 cm.
- And most of the world's desertification land receive rainfall below this level.

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- For example, countries in Africa have been trying to create a barrier of trees, the **Great Green Wall (GGW)**, across the **Sahel region** **to stop the Sahara Desert from expanding**.
- GGW never bore fruit for the simple reason that plants did not survive in the absence of adequate water.

Agroforestry and community engagement could be a viable option

- In Niger smallholder farmers have protected and managed woody species that regenerate naturally on their farms. This has led to the creation of new agroforestry parklands on 5 mha.
- **Communities have played a major role in China**, which has a quarter of its land under deserts. **China is a global leader in greening deserts because of successful community engagement.**

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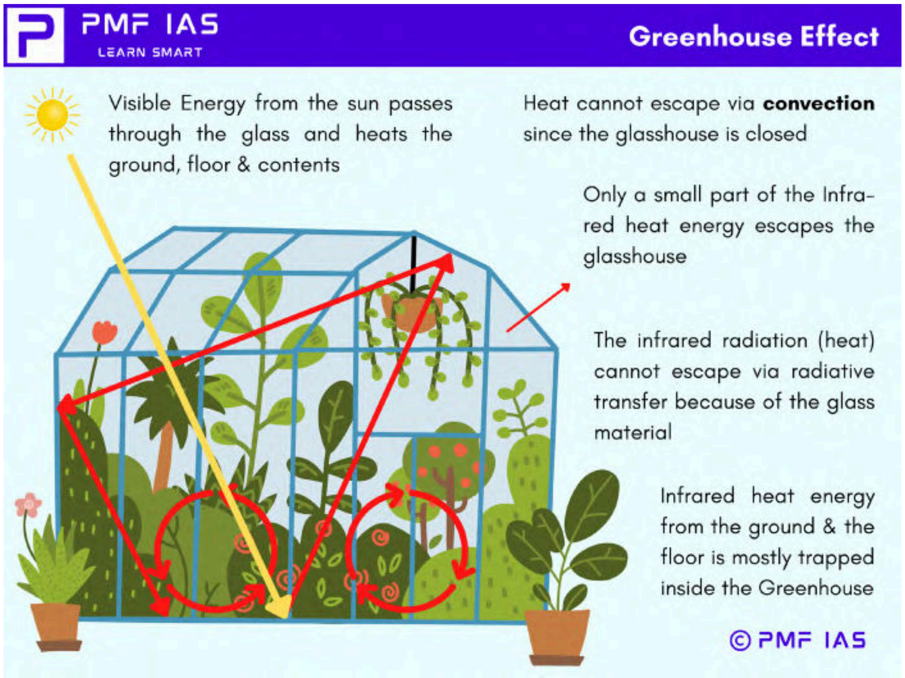
26. Global Warming and Climate Change

- Climate change means a change of climate which is attributed directly or indirectly to **human (anthropogenic) activity** that **alters the composition of the global atmosphere** and which is in addition to natural climate variability observed over comparable time periods (100 years).
- Climate change is usually measured in major shifts in temperature, rainfall, snow, and wind patterns lasting decades or more.
- Humans are causing climate change by burning large amounts of fossil fuels (coal, oil, natural gas), deforestation (when forests are cut down or burned, they **can no longer store carbon**, and the carbon is released into the atmosphere).

26.1. Greenhouse effect and Global Warming



26.1.1. Greenhouse Effect

- A greenhouse is a structure whose roof and walls are made chiefly of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown.
- In a greenhouse, the **incident solar radiation (the visible and adjacent portions of the infrared and ultraviolet ranges of the spectrum)** passes through the glass roof and walls and is absorbed by the floor, earth, and contents, which become warmer and **re-emit the energy as longer-wavelength infrared radiation (heat radiation)**.
- Glass and other materials used for greenhouse walls **do not transmit infrared radiation**, so the **infrared cannot escape via radiative transfer**.
- As the structure is not open to the atmosphere, heat also **cannot escape via convection**, so the temperature inside the greenhouse rises. This is known as the '**greenhouse effect**'.

26.1.2. Importance of Natural Greenhouse Effect

- The green-house effect is a natural phenomenon and has been occurring for millions of years on the earth.

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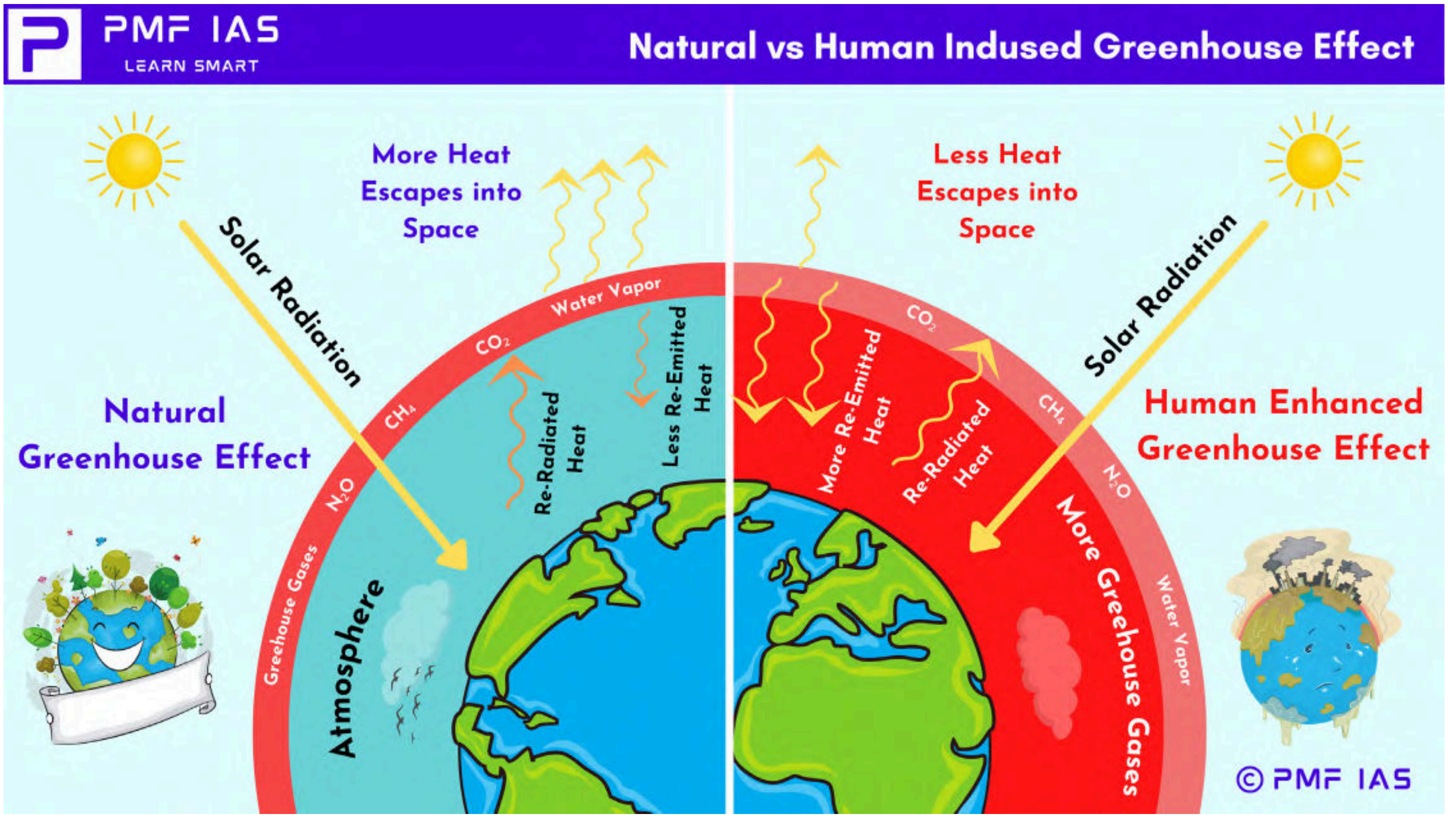
- Life on the earth has been possible because of this **natural greenhouse effect** which is due to **water vapour** and **small particles of water present** in the atmosphere.
- Together, these produce more than 95 percent of total greenhouse warming.
- Average global temperatures are maintained at about 15°C due to **natural greenhouse effect**.
- Without this phenomenon, average global temperatures might have been around –17°C and at such low temperature life would not be able to exist.



26.1.3. Natural vs. Human Induced Greenhouse Effect

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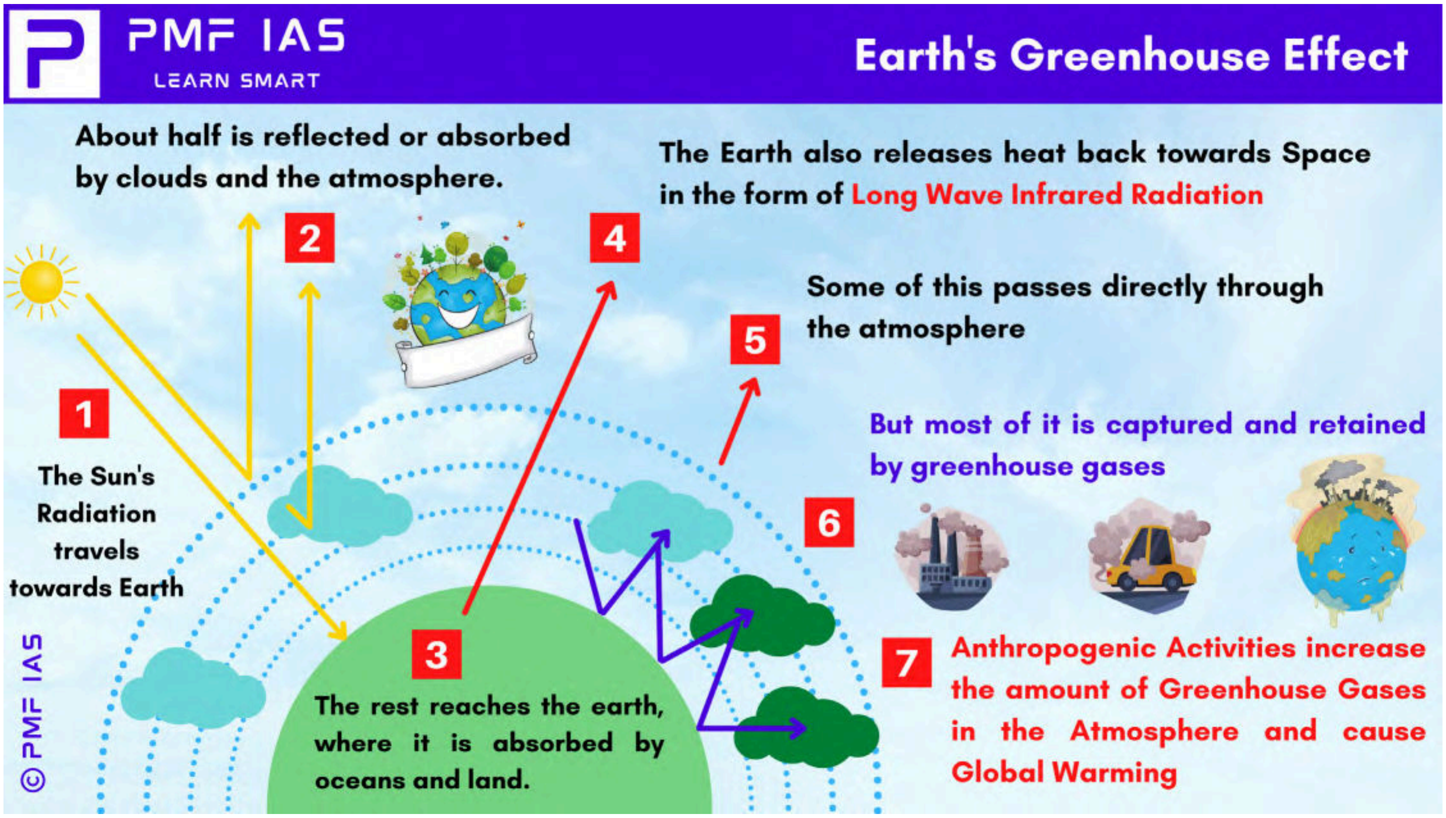
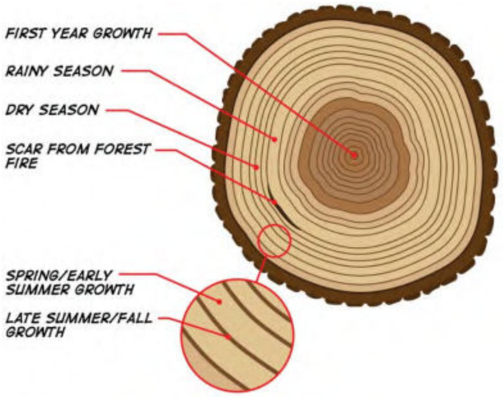


26.1.4. How do Scientists' Study Past Global Warming and Climate Changes Events?

Tree rings record earth's climate

- Trees can keep a record of Earth's climate (hundreds or even thousands of years).
- These rings tell us **how old the tree is**, and what the **weather** was like during each year of the tree's life.
- One light ring plus one dark ring equals one year of the tree's life.
- The light rings represent wood that grew in the early summer, while the dark rings represent wood that grew in the late summer.
- The **colour and width of tree rings** can provide snapshots of past climate conditions.
- For example, tree rings usually grow wider during wet years, and they are thinner in dry years.



The colour and width of tree rings indicate past climate conditions

Ice cores from cryosphere

- Ice core (a long column of ice) is extracted by drilling deeply into glaciers and ice sheets.
- Ice cores hold a record of what our planet's climate was like hundreds of thousands of years ago.

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- Ice sheets and glaciers near Poles are formed from years and years of accumulating snowfall.
- Each layer of ice tells a story about what Earth was like when that layer of snow fell.

- The icy layers hold **air molecules, GHGs and aerosols** such as dust, ash, pollen, sea salts of that time.
- These particles provide evidence of past global events, such as climate change, major volcanic eruptions, etc.

26.2. Greenhouse Gases (GHGs) and Global Warming

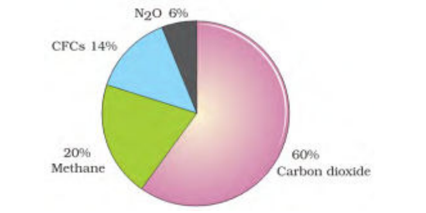
- Atmospheric gases like **carbon dioxide, methane, nitrous oxide (N_2O), water vapour,** and **chlorofluorocarbons** can trap **the out-going infrared radiation** from the earth's surface thereby causing **greenhouse effect**.
- Hence these gases are known as **greenhouse gases** and the heating effect is known as **greenhouse effect**.
- If greenhouse gases are not checked, by the turn of the century the temperature may rise by **5°C**.
- Scientists believe that this rise in temperature will lead to deleterious changes in the environment and resulting in odd climatic changes (e.g., increased incidence of El Nino), thus leading to increased melting of the **cryosphere** (polar ice caps as well as other places like the Himalayan snow caps).
- Over many years, this will result in a **rise in sea level** that can submerge many coastal areas and lead to **loss of coastal areas and ecosystems** like **swamps and marshes** (most important ecosystems from the point of ecological services), etc.

Greenhouse Gas	Sources and Causes
Carbon dioxide (CO_2)	Burning of fossil fuels, deforestation
Chlorofluorocarbons (CFCs)	Refrigeration, solvents, insulation foams, aero propellants, industrial and commercial uses
Methane (CH_4)	Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuel, wood, landfills, wetlands, fertilizer factories.
Nitrous Oxide (N_2O)	Burning of fossil fuels, fertilizers; burning of wood and crop residue.
Carbon Monoxide (CO)	Iron ore smelting, burning of fossil fuels, burning e-waste.

26.2.1. Global Warming Potential (GWP) & Lifetime of Green House Gases

- Global warming potential (GWP) is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide (CO_2).

Gas	GWP (100-year)	Lifetime (years)
Carbon dioxide	**1**	**50-200**
Methane	**21**	**12**
Nitrous oxide (N_2O)	**310**	**120**
Hydrofluorocarbons (HFCs)	**140 -11,700**	**1-270**
Perfluorocarbons (PFCs)	**6,500-9,200**	**800-50,000**
Sulphur hexafluoride (SF_6)	**23,900**	**3,200**



Relative contribution of various greenhouse gases to total global warming

26.2.2. Carbon Dioxide

- Carbon dioxide is a meteorologically important gas as it is **transparent to the incoming solar radiation but opaque to the outgoing terrestrial radiation**.

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- Being an **efficient absorber of ifrared radiation (heat),** it absorbs a part of terrestrial radiation and reflects some part of it towards the earth's surface.
- It is **largely responsible for the greenhouse effect** and **heat energy budget**.
- Its concentration is **greater close to the earth's surface** as it is **denser than air**.
- In May 2019, global concentration of CO_2 in the atmosphere was measured to have crossed the **415 parts per million (ppm)**.
- Atmospheric carbon dioxide measured at **NOAA's Mauna Loa Atmospheric Baseline Observatory** (Hawaii) peaked for 2021 in May at a monthly average of **419 parts per million (ppm)**.

How much Carbon is there on the Earth?

- US National Academy of Sciences has released a series of papers estimating the total carbon on Earth.
- This includes an analysis of the total CO_2 released by **volcanoes which contribute much less than human activities**.
- Humanity's annual carbon emissions through the burning of fossil fuels and forests, etc, are **40 to 100 times greater than all volcanic emissions**.

1.85 Billion Gigatons (Gt) of total carbon on Earth	
Below the Surface	**Above the Surface**
• 1.845 Billion Gt of the total carbon on Earth is below the surface. • Of this, 315 Million Gt of carbon is in continental and oceanic lithospheres.	• **43,500 Gt** of the total carbon on Earth is above the surface. 1. **37,000 Gt in the deep ocean (85.1 %)** 2. **3,000 Gt in marine sediments (6.9%)** 3. **2,000 Gt in terrestrial biosphere (4.6%)** 4. **900 GT in the surface ocean (2%)** 5. **590 Gt in the atmosphere (1.4%)**

26.2.3. Ozone

- Ozone is another important greenhouse gas. But it is in **very small proportions at the surface**.
- Most of it is confined to the **stratosphere** where it **absorbs the harmful UV radiation**.
- At ground level, pollutants like carbon monoxide, nitrogen dioxide and **volatile organic compounds (VOC – oil & gas extraction) convert O_2 to tropospheric ozone (O_3) in the presence of sunlight.**

Q. Consider the following: (2019)

1. Carbon monoxide
2. Methane
3. Ozone
4. Sulphur dioxide

Which of the above are released into the atmosphere due to the burning of crop/biomass residue?

a) 1 and 2 only
b) 2, 3 and 4 only
c) 1 and 4 only
d) 1,2,3 and 4

Explanation:

- Ozone is not released directly. It is a secondary pollutant.
- Burning of biomass releases CO, methane and sulphur dioxide.

Answer: d) all

26.2.4. Water Vapour

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- Water Vapour is one of the most variable gaseous substances present in atmosphere – constituting between **0.02% and 4%** of the total volume (in cold dry and humid tropical climates respectively).
- Water vapour is also a variable gas in the atmosphere, which decreases with altitude.
- 90% of moisture content in the atmosphere exists within 6 km of the surface of the earth.
- Water vapour also decreases from the equator towards the poles.
- Like carbon dioxide, water vapour plays a significant role in the insulating action, of the atmosphere.
- It **absorbs** not only the **long-wave terrestrial radiation** (**infrared or heat emitted by earth** during nights), but also a part of the **incoming short-wave solar radiation (visible and UV radiation)**.

Q. The increasing amount of carbon dioxide in the air is slowly raising the temperature of the atmosphere, because it absorbs

a) the water vapour of the air and retains its heat.
b) the ultraviolet part of the solar radiation.
c) all the solar radiations.
d) the infrared part of the solar radiation

Explanation:

- Among GHGs, **only water vapor can absorb both incoming (UV) and outgoing (infrared) radiation**.

Answer: d) the infrared part of the solar radiation (outgoing radiation).

26.2.5. Methane

- Methane is the **most important greenhouse gas after carbon dioxide**. It is an **odourless, colourless, tasteless gas** that is **lighter than air**.
- The **20-year global warming potential** of methane is **84** i.e., over a 20-year period, **it traps 84 times more heat per mass unit than carbon dioxide (CO_2) — it is a more potent GHG than CO_2**.
- However, **its lifetime** in the atmosphere is **much shorter** than **carbon dioxide (i.e., it is short lived)**.

Methane emissions from Global Food Systems

- Currently, global food system is responsible for **one third of the world's greenhouse gas emissions**.
- At present, a waste of food items is **one-third** of the global food production.
- Rotting food, animal waste, biomass, etc. release **Methane** (greater global warming potential than CO_2).
- A lot of water, especially ground water, and energy (coal electricity) goes into food production.

26.2.6. Nitrous Oxide (N_2O)

- **Nitrous Oxide (N_2O)** is **a greenhouse gas 300 times more potent than carbon.**
  - ⇨ ***Nitrogen Oxide (NO), Nitrogen dioxide (NO_2) are global cooling gasses***
  - ⇨ ***Nitrous Oxide (N_2O) is a greenhouse gas***
  - ⇨ ***They all fall under the general formula for oxides of nitrogen (NO_x)***

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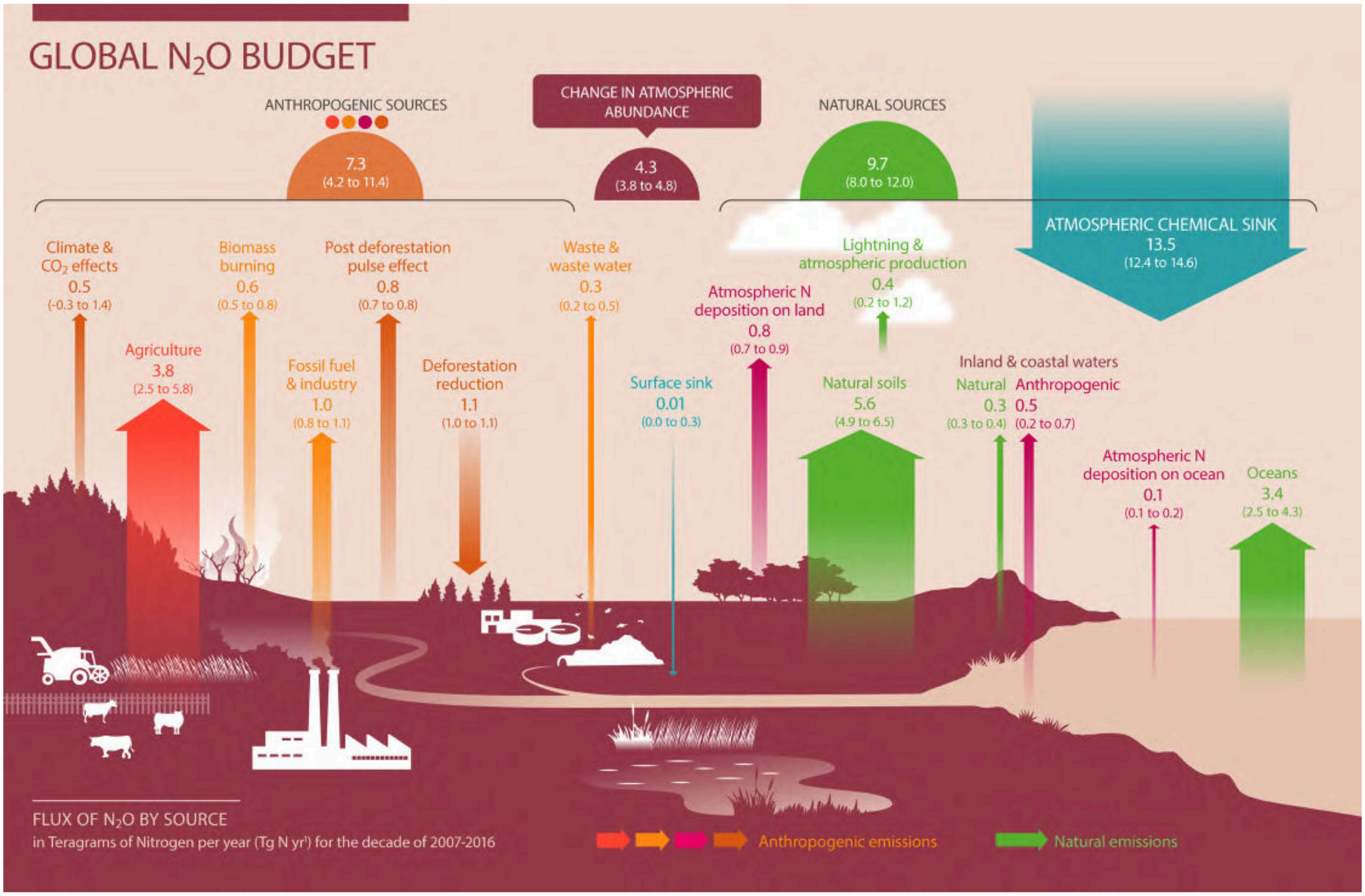

Human Emissions of Nitrous Oxide (N_2O) is Increasing

- **Nitrous Oxide (N_2O)** emissions have increased by **30 per cent** between **1980 & 2016**.
- It has the **third-highest concentration after CO2 & methane** in our atmosphere among greenhouse gases responsible for global warming.
- N_2O can live in the atmosphere for up to **125 years (long-lived just like CO_2)**.
- **43 per cent** of the total emissions of N_2O came from **human sources**, a major portion of it from the **agricultural sector** (**nitrogen-based fertilisers)**.
- Most N_2O emissions have come from emerging countries like **India, China & Brazil**.
- **N_2O** is also the only **remaining threat to the ozone layer**, as it is long-lived in the atmosphere.
- **Agriculture accounts for over 70% of all nitrous oxide emissions** in the Indian environment, of which **77% is contributed by fertilisers, mostly urea**.

26.2.7. Black Carbon (Soot)

- Black carbon warms the earth by **reducing albedo** (the ability to reflect sunlight) when deposited on snow.
- It is the **strongest absorber of sunlight (a lot more than carbon dioxide) and heats the air directly**.
- Black carbon is said to be the **second-largest contributor to climate change after CO_2**.
- But unlike CO_2, which can stay in the atmosphere for years together, **black carbon is short-lived** and remains in the atmosphere only for days to weeks before it descends as rain or snow.

26.2.8. Fluorinated Gases

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Chlorofluorocarbons (CFCs)

- **CFCs** were **phased out via the Montreal Protocol** due to their part in **ozone depletion**.
- These anthropogenic compounds are also a greenhouse gas, with a much **higher potential to enhance the greenhouse effect** than CO_2.

Hydrofluorocarbons

- Hydrofluorocarbons are used as **refrigerants, aerosol propellants, solvents, and fire retardants**.
- These chemicals were developed as a **replacement for chlorofluorocarbons (CFCs)**.
- Unfortunately, HFCs are **potent greenhouse gases with long atmospheric lifetimes**.

Perfluorocarbons

- **Perfluorocarbons** are a group of human-made chemicals composed of **carbon and fluorine only**.
- Perfluorocarbons are powerful greenhouse gases that were introduced as alternatives to CFCs in manufacturing semiconductors.
- Perfluorocarbons are compounds produced as a **by-product in aluminium production** and the **manufacturing of semiconductors**.
- Like HFCs, PFCs generally have **long atmospheric lifetimes** and **high global warming potential**.

Sulphur Hexafluoride

- **Sulphur hexafluoride** is also a **greenhouse gas**.
- Sulphur hexafluoride is used in **magnesium processing and semiconductor manufacturing**, as well as a **tracer gas for leak detection**.
- Sulphur hexafluoride is used in electrical transmission equipment, including **circuit breakers**.

26.2.9. Carbon Monoxide

- Carbon monoxide is a **short-lived very weak direct greenhouse gas (it is less dense than air)**.
- It has an **indirect radiative forcing** effect by **elevating concentrations of methane (GHG)** and **tropospheric ozone (GHG)**.
- Through natural processes in the atmosphere, it is eventually **oxidized to carbon dioxide**.

26.3. Carbon Footprint

- **Carbon footprint** is a measure of the impact one's activities have on the amount of CO_2 produced through the burning of fossil fuels and is expressed as a **weight of CO_2 emissions produced in tonnes**.
- It is measured during the course of a year & can be associated with an individual, organization, product etc.
- India has pledged a **33-35% reduction in the emissions intensity (carbon footprint)** of its economy by **2030 compared to 2005 levels**.

26.3.1. Carbon Footprint of various Sectors

- World Resources Institute (WRI) breaks down total global emissions from 2005 into the following headline sectors:

1. **Energy**
    1) **Electricity & heat (24.9%)**
    2) **Industry (14.7%)**
    3) **Transportation (14.3%)**
    4) **Other fuel combustion (8.6%)**

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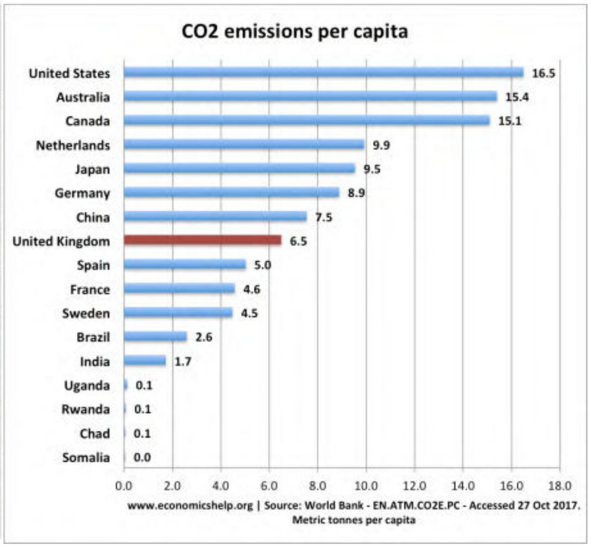
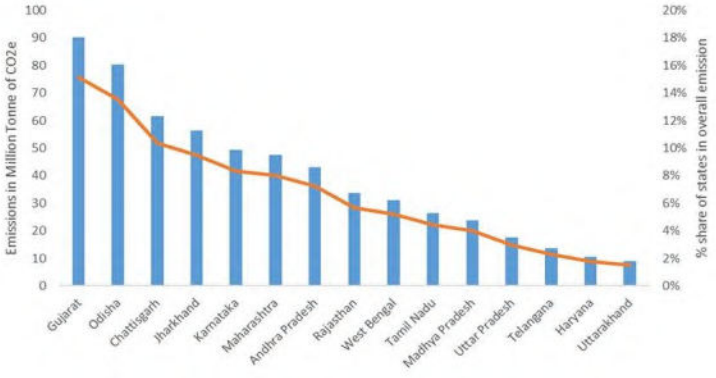
   5) **Fugitive emissions (4%)**
2. **Agriculture (13.8%)**
3. **Land use change (12.2%)**
4. **Industrial processes (4.3%)**
5. **Waste (3.2%)**

Country	2018 CO2 Emissions in Billion Metric Tons	Global Share	Change Since Kyoto Protocol
China	9.43	27.8%	54.6%
U.S.	5.15	15.2%	-12.1%
India	2.48	7.3%	105.8%
Russia	1.55	4.6%	5.7%
Japan	1.15	3.4%	-10.1%
Germany	0.73	2.1%	-11.7%
South Korea	0.70	2.1%	34.1%
Iran	0.66	1.9%	57.7%
Saudi Arabia	0.57	1.7%	59.9%
Canada	0.55	1.6%	1.6%



26.3.2. State Wise Carbon Emissions in India



- Largest contribution of CO emissions come from **Maharashtra, West Bengal** and **Gujarat**.
- **Electricity generation:** Contributed to **35.5% of total CO_2 emissions in 2010-2015**.
- **Road transport:** Maharashtra's annual contribution is the highest followed by Gujarat and Uttar Pradesh.
- **Cement and steel industries**: Major sources of industrial CO_2 emissions are from **Rajasthan, Andhra Pradesh**, Tamil Nadu and Madhya Pradesh and are major producers (57% of total cement in the country).
- **Steel industries** are distributed in Chhattisgarh, Jharkhand, Maharashtra and Gujarat.
- **Agriculture:** methane emissions from biomass is highest in **Uttar Pradesh**, Punjab, West Bengal, Madhya Pradesh and Andhra Pradesh.

Carbon watch for Climate Smart Citizens

- **Chandigarh** became the first state/UT in India to launch the **Carbon watch**, a **mobile application** to assess the **carbon footprint of an individual**.
- An individual is asked details on four segments namely water, energy, waste generation and transport.
- With the above-mentioned details, the mobile application calculates the carbon footprint of the individual.
- The application also provides the individual's contribution to national and world average emissions.

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- The app will suggest methods to reduce carbon footprints on the basis of information furnished.
- The goal of the app is to make people **Climate smart citizens**.

26.4. Climate Sensitivity

- Climate sensitivity is defined as the **global temperature rise following a doubling of CO_2 concentration** in the atmosphere compared to pre-industrial levels.
- If we know what the climate sensitivity is, it will help us estimate how much CO_2 we can emit and still stay below **2°C of warming – as per the Paris Agreement**.
- Pre-industrial CO_2 was about **260 ppm**, so a doubling would be at roughly **520 ppm**.
- The recent atmospheric concentration of CO_2 was found to be at **419 ppm**.
- That is, our atmosphere now contains about **45% more CO_2 than it did before the Industrial Revolution**.
- The **520 ppm threshold** is expected in the next 50-100 years depending on future GHG emissions.

26.4.1. Feedbacks Drive Uncertainty

- Climate sensitivity has been in the range of 1.5°C to 4.5°C. It is now moving to between 3°C and 7°C.
- The wide range of estimates of climate sensitivity is driven by **uncertainties in climate feedbacks**, including how **water vapour, clouds, surface reflectivity (albedo)**.
- Climate feedbacks are processes that may **amplify (positive feedbacks)** or **diminish (negative feedbacks)** the effect of warming from increased CO_2 concentrations or other climate forcing.
- **Cloud-related feedbacks** included in newer models are responsible for higher levels of predicted warming.

Permafrost

- Earth itself begins releasing stores of greenhouse gases **(CO_2 and Methane)** from **melting permafrost**.
- And the melting of permafrost will raise the temperature creating a **positive feedback**.

Water vapour

- As the world warms, the amount of water vapour in the atmosphere is expected to increase and, therefore, so too will the greenhouse effect.
- Measurements from satellites confirm that water vapour concentrations have been increasing in step with temperatures in the atmosphere over the past few decades.

Clouds

- A warmer and wetter atmosphere will also affect cloud cover.
- Clouds have a **dual effect** on our climate —
  1. they reflect part of the sunlight back into space, which decreases temperatures (**negative feedback**), &
  2. they trap part of the heat reflected from the earth's surface, which increases temperatures (**positive feedback**).
- The net effect depends on the type of cloud.
- **Clouds that contain more water droplets are "optically thicker"** and **more effective at blocking sunlight** than those composed mainly of **ice crystals (cirrus clouds)**.
- For example, **thick, low clouds are "strong coolers"** since they reflect a large part of solar radiation (sunlight) and absorb little heat from the ocean and land.
- On the other hand, **very thin, high clouds such as cirrus clouds reflect little sunlight**, but they are very **efficient at absorbing thermal radiation (heat), making them "strong warmers"**.
- Meanwhile a **shift in sun-blocking clouds (due to global warming)** from the tropics towards the poles, where the incoming sunlight is less intense, would decrease their power to block sunlight.

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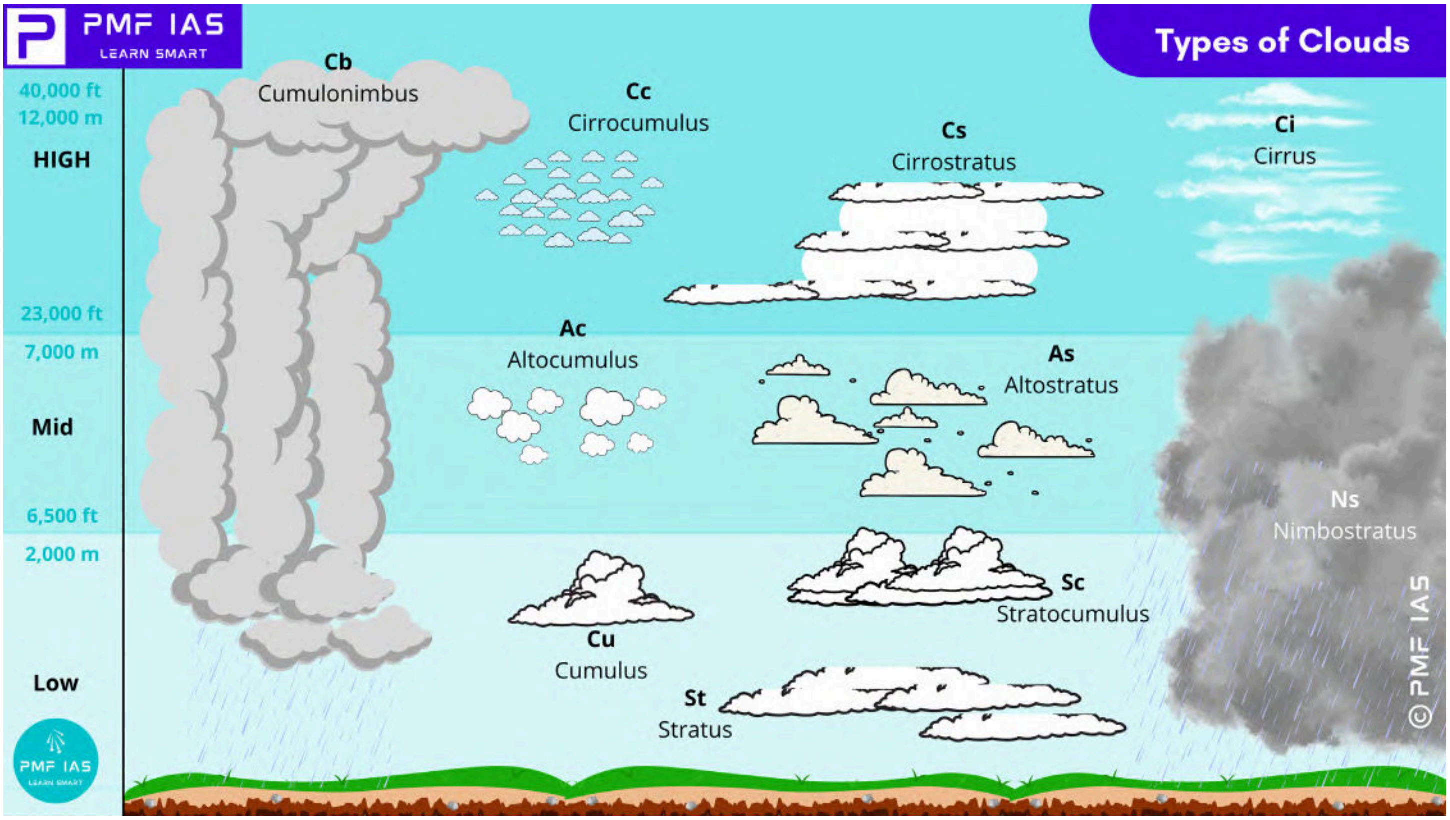
- All this means the global net effect of cloud feedbacks is complex and hard for scientists to model precisely.



26.5. International Energy Agency (IEA) World Energy Outlook 2021 Report

- Despite the **decline in 2020**, **global energy-related CO_2 emissions** remained at **31.5 Gt**, which contributed to CO_2 reaching its **highest ever average annual concentration** in the atmosphere of **412.5 parts per million in 2020** — around 50 per cent higher than when the industrial revolution began.

26.5.1. India Energy Outlook 2021

- The **International Energy Agency (IEA)** has released the **India Energy Outlook 2021** Report as a part of **IEA's World Energy Outlook** series.
- According to the report, CO_2 emissions in India are now broadly on par with the EU at **2.35 gigatonne (billion tonne)**, although they remain **two-thirds lower on a per capita basis** and **60% below the global average**.
- India will overtake the **European Union** as the world's **third-biggest energy consumer** by 2030.
- India at present is the fourth-largest global energy consumer behind **China**, the **United States**, and the **European Union**. (India is the **3rd highest energy consuming country in the world**).
- Industrialisation is a major driving force behind the rise in India's energy consumption.
- Over 80% of India's energy needs are met by three fuels: **coal, oil,** and **solid biomass**.
- **Coal** remains the **largest single fuel** in the energy mix.
- Oil consumption and imports have grown rapidly.
- Biomass, primarily fuelwood, makes up a declining share of the energy mix, but is still widely used.
- Despite recent success in expanding coverage of LPG in rural areas, 660 million Indians have not fully switched to modern, clean cooking fuels or technologies.
- The installed renewable energy generation capacity as of March 2021 stands at only 94 GW.

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26.5.2. International Energy Agency (IEA)

- The IEA is an **autonomous Intergovernmental Organisation** established in 1974 in Paris, France.
- It was established in the framework of the Organisation for Economic Co-operation and Development (OECD) in 1974 in the wake of the 1973 oil crisis.
- IEA mainly focuses on energy policies that influence economic development, energy security and environmental protection. These policies are also known as the **3 E's of IEA**.
- Only OECD member states can become members of the IEA.
- Indian and China are not its members.
- India became an Associate member of IEA in March 2017
- The **World Energy Outlook Report** is released by the **IEA annually**.

26.6. UNEP Emissions Gap Report 2020

- The United Nations Environment Programme (UNEP), releases **Emissions Gap Report annually**.
- It measures the **gap between what we need to do & what we are actually doing** to tackle climate change to keep earth's temperature according to **Paris agreement**.

26.6.1. Findings from the Emission Gap Report 2020 on key aspects

- The world is heading for a temperature rise **in excess of 3°C this century**.
- Global GHG emissions **continued to grow** for the third consecutive year in 2019.
- GHG emissions **fell for the first time in 2020 due to the pandemic**.
- Since 2010, global GHG emissions have grown 1.4% per year on average, with a **more rapid increase of 2.6% in 2019** due to a large **increase in vegetation forest fires**.
- Fossil **carbon dioxide (CO_2)** emissions dominated total GHG emissions.
- Over the last decade, the **top four emitters** (**China, the United States of America, EU27+UK & India**) have contributed to 55 per cent of the total GHG emissions without LUC (land-use change).
- Rich countries have higher **consumption-based emissions** than territorial-based emissions.
- **Consumption-based emissions:** Emissions allocated to the country where goods are purchased & consumed, rather than where they are produced.

26.6.2. Solutions

- Green pandemic recovery by **increasing net zero emission** can cut the emissions.

Combining a green pandemic recovery with NDCs under the Paris Agreement.

Measures to prioritize in green fiscal recovery include:

- ✓ Direct support for zero-emissions technologies & infrastructure,
- ✓ Reducing fossil fuel subsidies,
- ✓ No new coal plants, &
- ✓ Promoting nature-based solutions – including large-scale landscape restoration & reforestation.

- **Decarbonisation of energy sector** based on renewable energy & phasing out coal fired power plants.

26.6.3. Climate Change Performance Index (CCPI) 2021

- CCPI is Published by **Germanwatch**, the **New Climate Institute** & the **Climate Action Network annually** since 2005.

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- The CCPI looks at **four categories,** with 14 indicators:
  - ✓ **Greenhouse Gas Emissions** (40% of the overall score),
  - ✓ **Renewable Energy** (20%),
  - ✓ **Energy Use** (20%), &
  - ✓ **Climate Policy** (20%).
- Globally, **no country had met the criteria** to get placed high enough on the index.
- Top three ranks were empty.
- Only two G20 nations, the **UK & India** are among the **high rankers in CCPI 2021**, which covers 2020.
- **India ranked 10th**. India received high ratings in all CCPI indicators **except renewable energy**.
- China, the biggest emitter of greenhouse gases, is ranked at the 33rd position on the CCPI 2021 report.

26.7. Intergovernmental Panel on Climate Change (IPCC)

- The IPCC is the UN body for **assessing the science related to climate change**.
- It was established by the **United Nations Environment Programme (UNEP)** and the **World Meteorological Organization (WMO)** in 1988.
- The IPCC produces reports that support the **UNFCCC**.
- IPCC reports cover all relevant information to understand the risk of human-induced climate change, its potential impacts & options for adaptation and mitigation.
- The IPCC **does not carry out its own original research**.
- Thousands of scientists and other experts contribute on a voluntary basis.

26.7.1. IPCC Assessment Reports (AR)

- The IPCC prepares at regular intervals comprehensive **Assessment Reports** for the understanding of **human induced climate change**, potential impacts and options for mitigation and adaptation.

The IPCC has three working groups

- The IPCC work is shared among **three Working Groups**, a Task Force and a Task Group.
  1. WG I aims at assessing the physical **scientific basis** of the climate system and climate change.
  2. WG II assesses the **vulnerability** of socio-economic and natural systems to climate change.
  3. WG III focuses on climate change **mitigation**, assessing methods for reducing GHG emissions, and removing greenhouse gases from the atmosphere.
- The IPCC is currently in its **6th Assessment Cycle**, during which the IPCC will produce the
  - ✓ **Assessment reports of its three working groups**,
  - ✓ **three special reports (SR1.5, SRCCL & SROCC)**,
  - ✓ a **refinement to the methodology report** and
  - ✓ the **Synthesis report**.
- The **Synthesis Report** will be the last of the **AR6** products, due for release in 2022.

Special Reports

- Special Reports have been prepared on topics such as regional impacts of climate change, CO_2 capture and storage and on the relationship between safeguarding the ozone layer and the global climate system.
- IPCC Panel decided in 2016 to prepare **three Special Reports**:
  1. **Special Reports on Global Warming of 1.5 °C (SR1.5 – October 2018)**,
  2. **Special Report on Climate Change and Land (SRCCL – August 2019)**, and

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3. **Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC – September 2019)**

26.7.2. Special Reports on Global Warming of 1.5 °C (SR1.5 – October 2018)

- SR1.5 said it was possible to keep the rise in temperature to **within 1.5 °C** if the world brings down its GHG emissions to **half of its 2010 levels by 2030 (45 per cent by 2030)**, and to **net zero by 2050**.
- At the current rate of emissions the world is set to breach the limit of 1.5 °C between 2030 and 2052.
- **Net-zero** is achieved when the total emissions is balanced by the amount of absorption of CO_2 through natural sinks, or removal of CO_2 from the atmosphere through technological interventions.
- Some countries have already announced their intention to achieve the net zero target, but the most prominent emitters — **China, US, India — have so far not done so**.

26.7.3. Special Report on Climate Change and Land (SRCCL – August 2019)

- The land report said the various kinds of uses that land was being put to — forestry, agriculture, industries, urbanisation — had contributed about **5.2 billion tonnes of CO_2 every year** between 2007 and 2016.
- During the same time, **trees and forests absorbed** almost **11.2 billion tonnes of CO_2 every year** from the atmosphere.
- The sum total of these two processes meant that land, and the vegetation on it, was removing about **6 billion tonnes of CO_2 from the atmosphere annually**.
- It also pointed out that the **global food system**, which would include agriculture, cattle-rearing, food processing, transportation & energy could account for as much as **a third of all greenhouse gases**.
- It said nearly **25 per cent** of all food produced globally was either lost or wasted.

26.7.4. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC)

- IPCC SROCC report updates scientific literature available since 2015 (since 5th Assessment Report).
- The SROCC report summarises the **disastrous impacts of warming** based on current projections of global GHG emissions.

Ocean warming

- The global ocean has taken up **more than 90% of the excess heat in the climate system**.
- Since 1993, the rate of ocean warming has more than doubled.
- **Marine heatwaves** have very likely doubled in frequency since 1982 and are increasing in intensity.
- The ocean is warming, becoming **more acidic** and **losing oxygen**.
- The rising temperatures are starving the upper layers of the water of **oxygen**, suffocating marine life, creating growing **dead zones**, and **disrupting the circulation of ocean currents** (disruptive weather on land).
- **Long lag times** at work in oceans mean that some of these changes will **inevitably intensify over centuries** — even if the world stopped emitting all its greenhouses gases tomorrow.

Sea Level Rise

- The sea levels are rising because of **thermal expansion of ocean waters** due to rising temperatures as well as **due to melting of glaciers and polar ice**.
- Globally sea levels are estimated to rise **1.1 metre by 2100**, if countries are not able to restrict emissions "well below" **2°C above pre-industrial levels**, as stated in the **2015 Paris climate agreement**.
- But, even if countries are able to restrict emissions, it is still estimated to rise 30-60 centimetres by 2100.
- Fifty per cent of coastal wetlands have already been lost over the last 100 years.

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Cryosphere

- The **cryosphere** is the frozen water part of the Earth water system.
- **Polar regions, snow caps of high mountain ranges** are all part of the cryosphere.
- Between 2006 and 2015, the Greenland ice sheet lost ice-mass at an average rate of **278 billion tonnes every year**, while the **Antarctic ice sheet lost a mass of 155 billion tonnes** on an average every year.
- Snow over areas outside of these two regions, like the glaciers in the Himalayas, together lost an average of **220 billion tonnes of ice every year**. (**Loss in Arctic > Loss in Himalayas > Loss in Antarctic**)
- In the Himalayas, glaciers feeding 10 rivers, including the **Ganges** and the **Yangtze**, could shrink dramatically if emissions do not fall, hitting water supplies across a swathe of Asia.
- **Thawing permafrost in places such as Alaska and Siberia** could **release vast quantities of greenhouse gases**, potentially unleashing feedback loops driving faster warming.

Suggested Solutions

- A relatively straightforward solution to curbing biodiversity loss, especially in the face of climate change, is expanding the global network of **large-scale protected areas on land and ocean**.
- The report also highlights an even more challenging component of the solution: **Rapid reduction of greenhouse gas emissions** must be achieved across institutional boundaries.
- The report calls for a **five-fold increase** in nationally determined contributions (NDCs), volunteered by countries under the 2015 Paris Agreement.

26.7.5. What is Carbon Budget?

- Global average temperature rise should not exceed 1.5°C if catastrophic climate change is to be avoided.
- To meet this goal, IPCC has set a limit on how much carbon the world can emit in the future. This limit is called the **carbon budget or the emissions budget**.
- The IPCC had estimated the carbon budget to be **2900 Gigatonnes (GT)** from the pre-industrial times to the end of the 21st century.
- But the world has already emitted **2,200 GT** by 2017 & can emit only 420/570 GT till century-end to avoid the breach.

26.7.6. Land use patterns and climate change

- IPCC has focused its attention solely on the **land sector** for its upcoming 2022 report.
- The latest report is part of a series of special reports that IPCC is doing in the run-up to the **sixth edition** of its main report called the **Assessment Reports**, that is due around 2022.
- The report presents the most recent evidence on how the different uses of land — forests, agriculture, urbanisation — are affecting and getting affected by climate change.

The contribution of land use patterns to climate change

- Activities like agriculture and cattle rearing are a major source of **methane** and **nitrous oxide** **(GHGs)**.
- If pre-production activities like cattle rearing and post-production activities like transport, food processing, is considered, then food production could contribute as much as **37% of all GHG emissions every year**.
- Overall food system contributes about **half of global emissions:**
  - ✓ **agriculture 15%,**
  - ✓ **deforestation for food 18%,**
  - ✓ **transportation, storage, processing, waste, etc 17%**

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- IPCC has appealed access to coarse grains, legumes, fruits and vegetables, nuts and seeds will have to be increased and the **carbon footprint caused by meat has to be reduced**.
- Nearly **25% of all food produced is either lost or wasted**. The decomposition of the waste releases GHGs.
- At the same time, soil, trees, plantations, and forests absorb carbon dioxide for the natural process of photosynthesis, thus reducing the overall carbon dioxide content in the atmosphere.
- This is the reason why **land use changes, like deforestation or urbanisation**, or even a **change in cropping pattern**, have a direct impact on the overall emissions of GHGs.

27. Impact of Global Warming

27.1. Increased Frequency and Severity of Heatwaves

- The unprecedented heatwave which has claimed hundreds of lives in **British Columbia (South-Western Canada)** and neighbouring **Washington and Oregon states (North-Eastern US)**, is the latest in a growing list of extreme weather events that are attributed to global warming.
- **Australia (2019-20), California (2020),** and **Siberia** have all recently experienced deadly wildfires caused by extreme heat waves.

27.1.1. Heat Wave

- A heat wave is a period of **excessively hot weather**.
- India Meteorological Department (IMD) declares heat waves when **actual maximum temperature remains 45 °C or more** regardless of normal maximum temperature.

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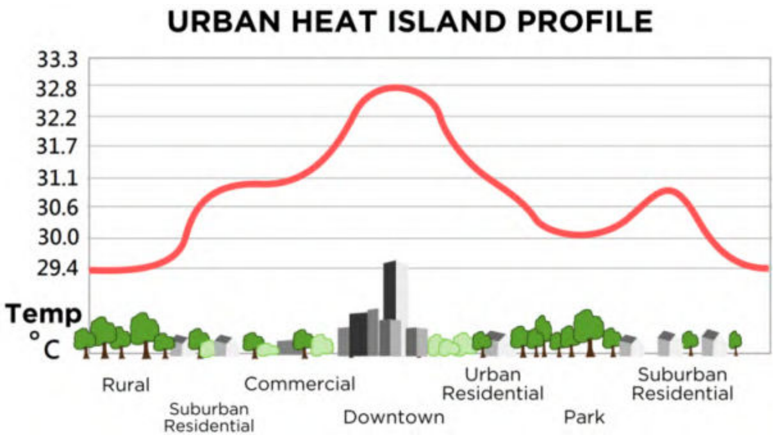
- Heat waves are caused due to **shifting of Jet Streams (Rossby Waves in the temperate region cause Heat Domes), hot local winds like loo (affects Gangetic Plains Region)**, and **anthropogenic causes like global warming**.

Global Warming and Heat Waves

- The global average temperature increase since 1900 is around **1.3 °C**, **in India it has crossed 2 °C**.
- As emissions continue to rise, India will suffer from heat waves more than the rest of the planet.
- IMD and the **Indian Institute of Tropical Meteorology (Pune)** have established that the **frequency and severity of heatwaves** have **risen** significantly in India over the last three decades.
- The impact of heatwaves is not limited to cities, but cities aggravate this phenomenon in the from **Urban Heat Islands**.

27.1.2. Urban Heat Islands



- An urban heat island is an urban or an industrial area that has temperatures considerably higher than its surrounding rural areas (both share the same climate) primarily due to anthropogenic reasons.

Causes Behind Urban Heat Islands

- Heat-trapping concrete and **asphalt (have very low albedo or low reflectivity)** replace natural vegetation and water (reduced evaporation and evapotranspiration).
- High rise buildings that offer **more surface area for heat absorption**.
- **High vehicle density** and a lot of heat released from their engines.
- **High pollution levels** and high concentration of GHGs like CO_2 (thermal power plants and vehicles).
- GHGs, aerosols, particulate matter, etc. are good at **absorbing outgoing infrared radiation**.
- Cooling appliances like **air conditioners** that release the heat into the surroundings.
- Bad monsoons: less evaporation of water from vegetation and soil.

Q. Bring out the causes for the formation of heat islands in the urban habitat of the world. (2013)

Urban heat islands at night

- Cities used to cool down during night, but nowadays they are trapping this heat overnight.
- ACs, pollution, close & dense network of buildings are the primary reason for the Urban heat islands at night.

Albedo of different surfaces

- **Albedo** of a surface is the proportion of sunlight that the surface can reflect back into space.
- Fresh snow has the highest albedo (reflects back 80-90% of the incident sunlight).
- **Dark asphalt** used to road construction and in roofing of buildings has very low albedo (~5%).

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Surface	Albedo
1. Fresh Snow	**80-90%**
2. Thick cloud	70-80%
3. Water near horizon	50-80%
4. Old Snow	45-50%
5. Desert	**30-45%**
6. Light soil	**20-45%**
7. Thin cloud	25-35%
8. Grasses	**20-25%**
9. Soil	**20-25%**
10. Crops	**10-25%**
11. Forest	**10-20%**
Asphalt (used in road construction & roofing)	**5%**
Numbers not important. Remember the descending order of Albedo.	

27.1.3. Heat Domes

- In July 2021, **Lytton in British Columbia (South-Western Canada)**, which lies in the temperate region, has endured record temperatures close to 50 °C.
- The blistering temperatures were caused by an **atmospheric high-pressure zone** known as a **heat dome**.
- The heat domes form several miles high in the atmosphere and **their air sinks down toward the ground**, **heating up because of compression**.
- Heat dome conditions arise when the jet stream, a band of fast-moving air high in the atmosphere, develops a large wave pattern (**Rossby Waves**) that keeps the **dome locked in place**.
- The jet stream's unusual behaviour in the last few decades is attributed to **climate change (1.3 °C warmer now than in 1990)**.
- Heat Domes are known to produce **high temperatures**, **violent thunderstorms (Pyrocumulonimbus Clouds)**, and **dangerous wildfires**.

Omega Block

- Heat domes often form what are known as **blocking patterns in the atmosphere**, which **halt the west-to-east movement of weather**.

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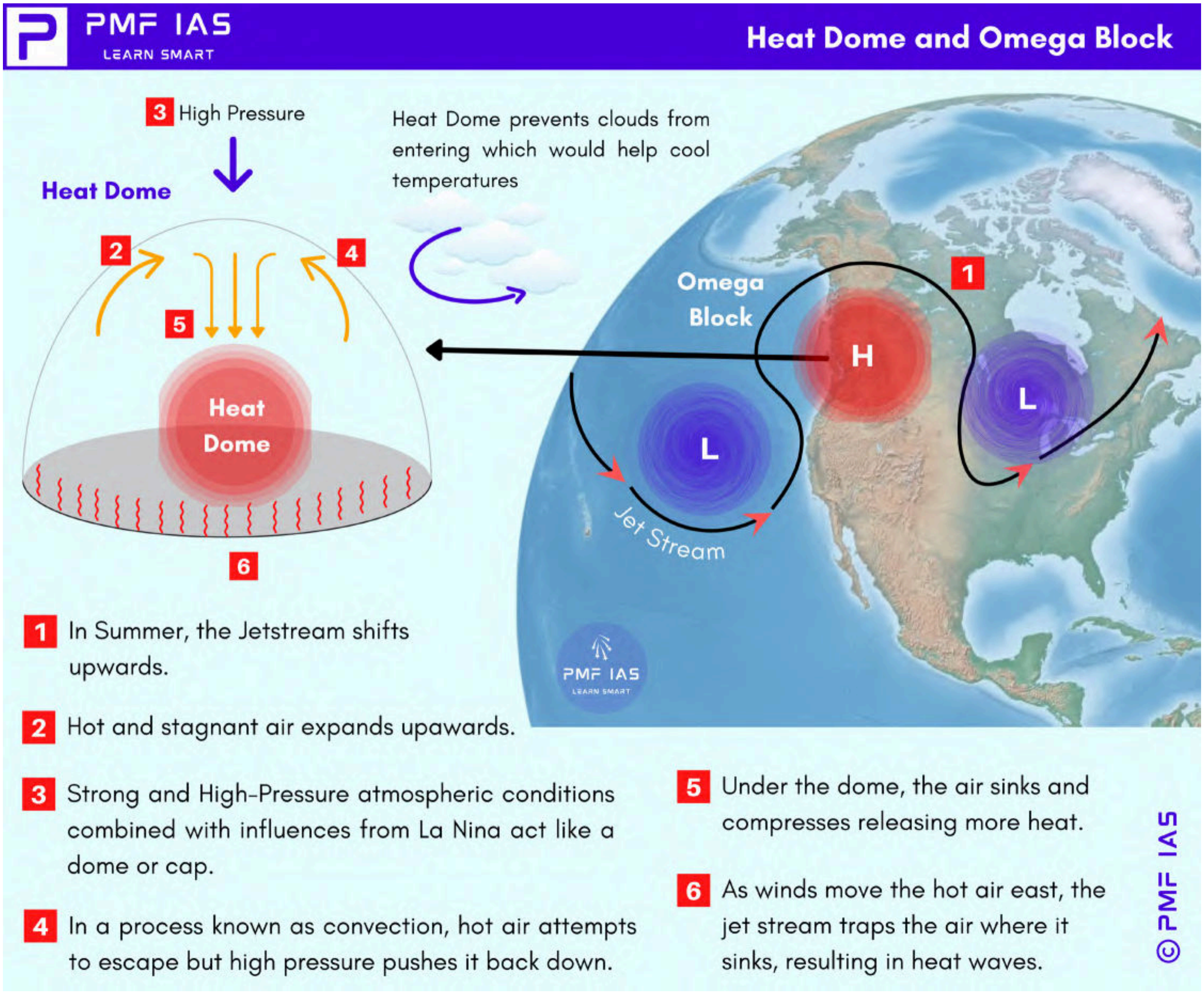

- One of the blocking patterns is called **omega block**. Omega blocks have been the main culprit for the **record-breaking heat in Canada this summer**.
- As the name suggests, the omega block takes on the shape of the Greek letter omega on a weather map.
- It is anchored by zones of **low pressure on its west and east sides**, flanking the **high-pressure zone or heat dome in the middle**.

27.1.4. Effects of Heat Wave

- **Sunstroke** (results in a body temperature greater than 40 °C) and vital organs failure.
- In 2015, over 2,300 people died in India reportedly as a result of heat waves.
- **Record heatwave in July 2021** has killed more than 500 people in **western Canada**.
- **Reduced human output** due to adverse effects on mental health (the body works best in a narrow range of body temperature — 36-37.5 °C).
- **Economic cost:** Increased expenditure on cooling appliances (**creates a positive feedback mechanism** and enhances global warming; heat wave ➔ more cooling appliances ➔ more emissions ➔ severe heat waves, and the cycle repeats).
- Ecological damage: reduced biological activity and carbon sequestration.

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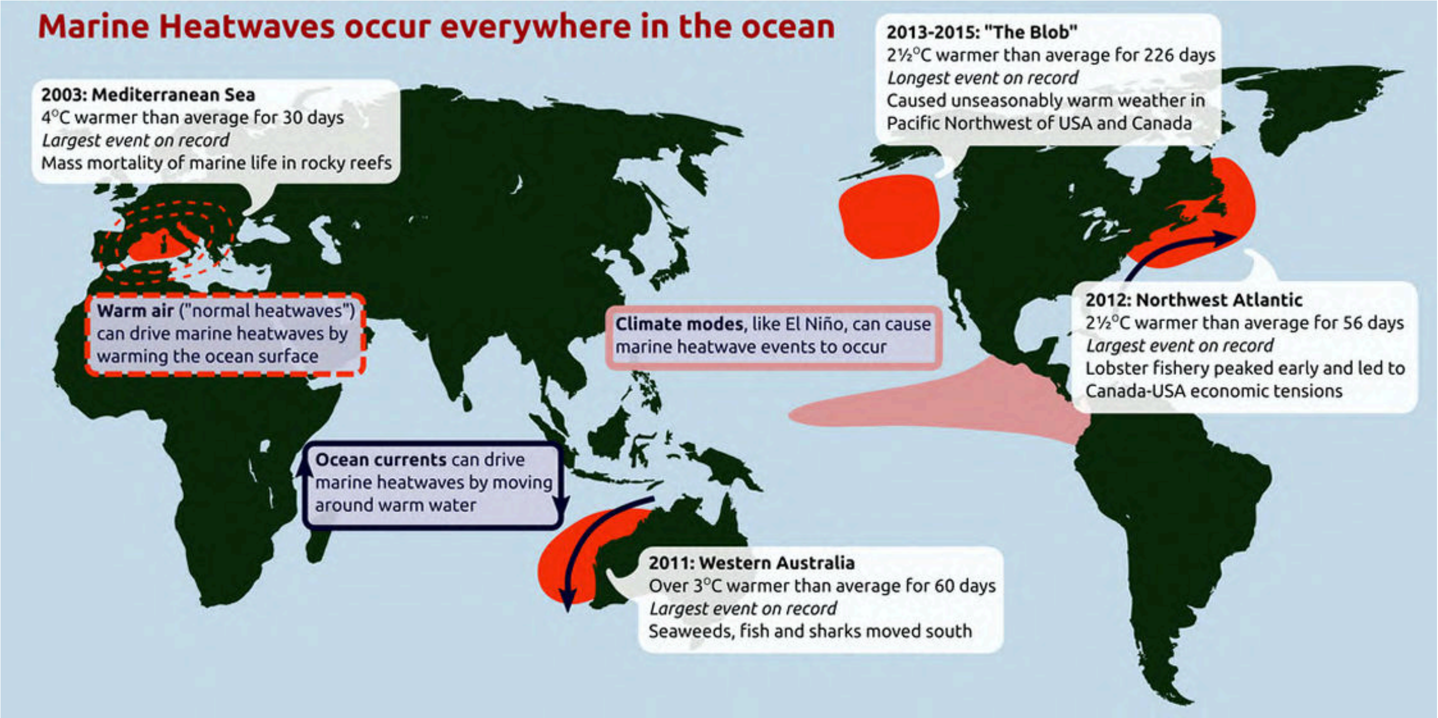
- Forest fires: one of the wort consequence of heat waves in the **temperate regions** are wildfires. This is evident in the **2019-2020 Australian Bushfires** and **July 2021 Western Canada Wildfires**.

27.2. Marine Heat Waves

Similar Topic in Mains 2019: How do ocean currents and water masses differ in their impacts on marine life and the coastal environment? Give suitable examples? (Answer in 250 words)

- **Marine heatwaves** occur when ocean temperatures for a particular oceanic location are **unusually extremely warm for an extended period** and time of year.
- Marine heatwaves can occur in **summer or winter** and have a significant impact on marine ecosystems and world weather patterns.



27.2.2. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) on Marine Heat Waves

- Today's oceans are experiencing unprecedented conditions with **increased temperatures, further** ocean acidification**, marine heatwaves** and **more frequent extreme El Niño and La Niña events**.
- Communities that live in close connection with coastal environments, **small island nations**, polar areas and high mountains are particularly vulnerable to changes, such as **rising sea levels** and **shrinking glaciers**.
- Communities in other areas are affected through **extreme weather events** exacerbated by ocean warming.

Marine heat waves

- Marine heat waves have become twice more frequent in the past four decades and are lasting longer.
- The report finds that **human activities** are responsible for 84 to 90 per cent of the marine heat waves that occurred in the last one decade.
- By 2081, the frequency of marine heat waves could jump by 20 to 50 times.

Impact on marine productivity

- Marine heat waves have resulted in **large-scale coral bleaching**, which takes more than 15 years for corals to recover from.

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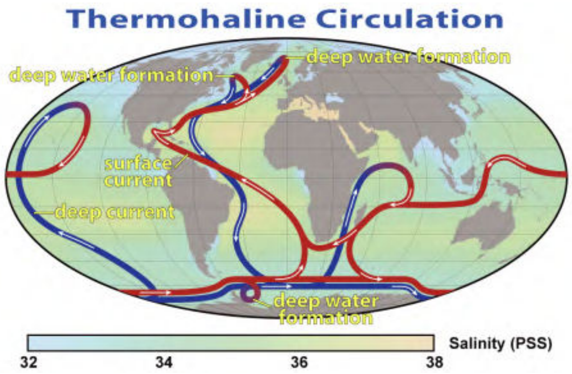
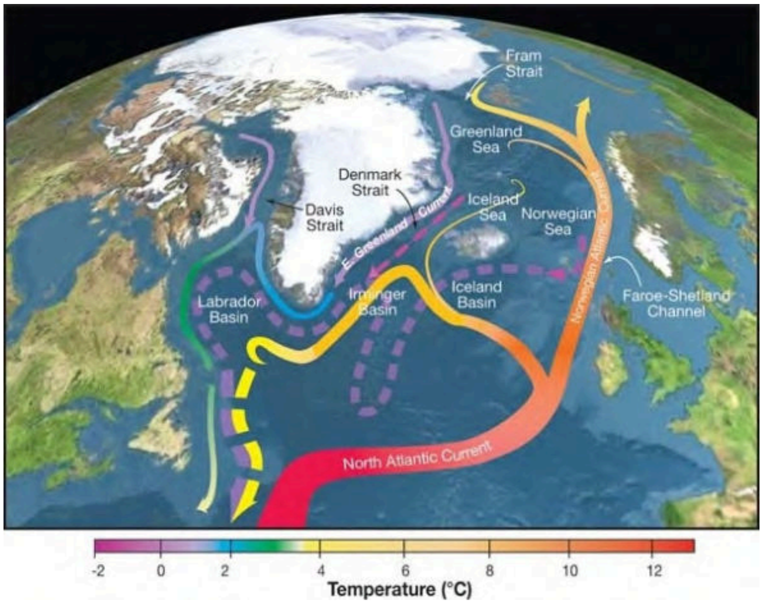
- Marine heat waves **reduce mixing between water layers** and, as a consequence, the **supply of oxygen and nutrients for marine life**.
- Pacific Ocean had seen such unusually warm water, it had **boosted the growth of toxin-producing algae** and **suppressed the growth of small organisms** at the **base of the ocean food chain**.

Impact on weather patterns

- The direct cause of marine heat waves is **weak winds**.
- A more pronounced effect of marine heat waves would be on global wind circulation and ocean currents.
- IPCC report indicates, the **Atlantic Meridional Overturning Circulation (AMOC)**, which ensures **northward flow of warm, salty water in the upper layers** of the Atlantic and a **southward flow of colder, deep waters**, has already weakened.
- Any substantial weakening of the AMOC would cause
  - ✓ further decrease in marine productivity in the North Atlantic,
  - ✓ more storms in Northern Europe,
  - ✓ **less Sahelian (southern part of Sahara Desrt) summer rainfall** and **South Asian summer rainfall**,
  - ✓ a reduced number of tropical cyclones in the Atlantic and
  - ✓ an **increase in regional sea level** along the northeast coast of North America, the report warns.





More severe cyclonic storms

- IPCC says there is an emerging evidence of an annual increase in percentage of category 4 and 5 storms.
- These storms further sustain their strength by feeding on the moisture over **warm ocean waters**.

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27.3. Increased Incidence of Wildfires

- Increased incidence of wildfire creates a **positive feedback loop** exacerbating global warming.

27.3.1. Australia's Bushfires are Getting Severe

- Australia, where the summer starts around October, is known to be the most fire-prone of all continents.
- This is mainly because Australia is also the driest inhabited continent. Almost 70 per cent of its area comprises arid or semi-arid land, with average annual rainfall less than 35 cm.
- Most of the Australia's forest land is in the north and east. Bushfires are common every summer in this region. But the fires in recent times are getting severe with each passing year due to climate change.
- In 2020, Australia has witnessed its worst drought and subsequent heat waves in more than five decades.
- This causes catastrophic fires and wildlife in Australia was severely hit with thousands of koala deaths.

Pyrocumulonimbus clouds

- The bushfires in Australia are generating so much heat that they are creating **pyrocumulonimbus clouds** — dry lightning storms and fire tornadoes
- Pyrocumulonimbus clouds have been recorded all over the world but as the **global climate changes**, they may become a more frequent occurrence.
- The pyrocumulonimbus clouds are essentially a **thunderstorm** (cumulonimbus cloud**)** that **forms from the smoke plume of a fire** as intense heat from the fire causes air to rise rapidly, drawing in surrounding air.
- As the cloud climbs and then cools in the low temperatures of the upper atmosphere, the collisions of ice particles in the higher parts of the cloud build up an **electrical charge**, which can be released as lightning.
- These can cause dangerous and unpredictable changes in fire behaviour, **making them harder to fight** as well as **causing lightning strikes that could ignite new fires**.
- The rising air also spurs **intense updrafts** that suck in so much air that strong winds develop, **causing a fire to burn hotter and spread further**.

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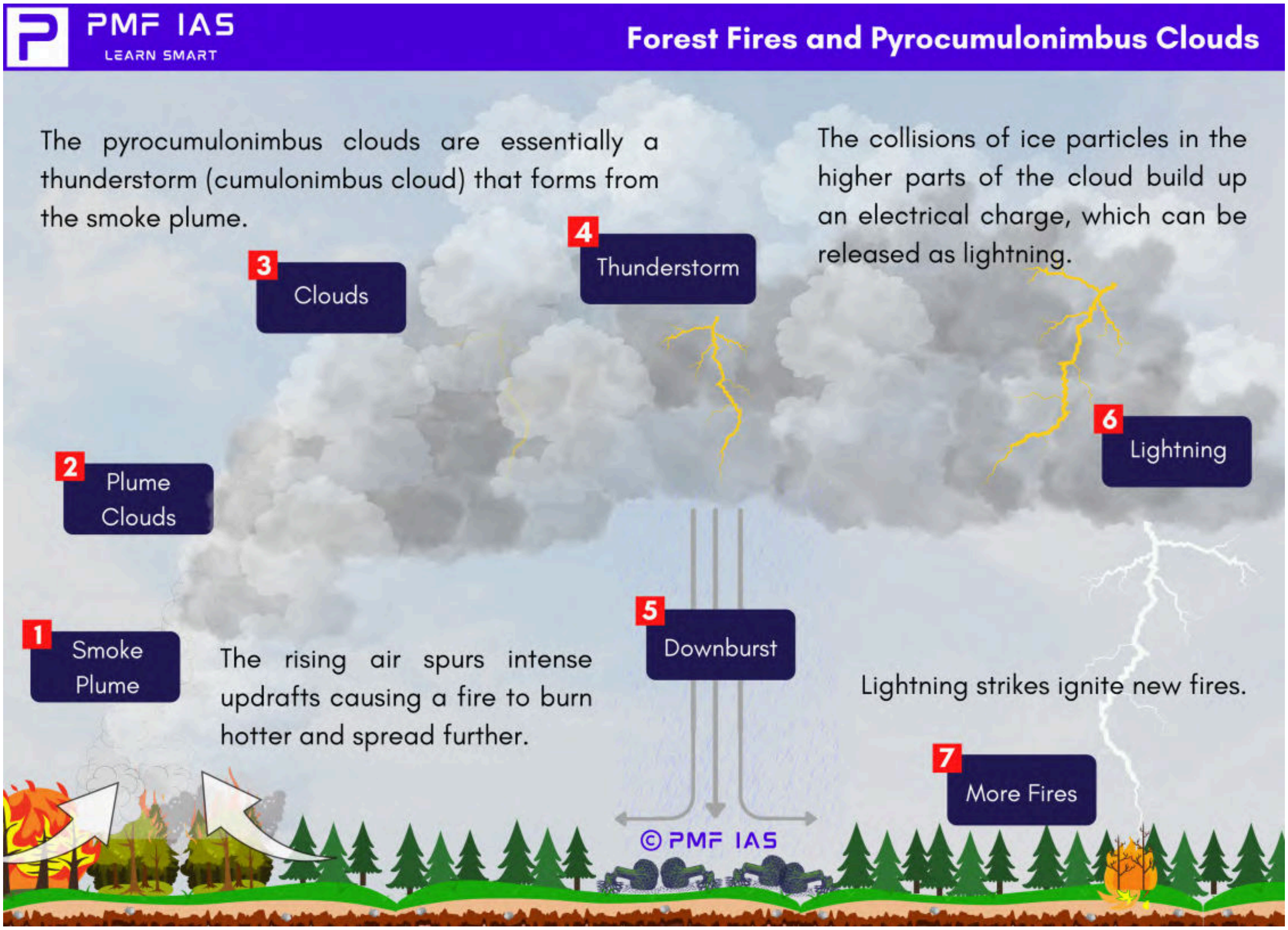

Criticism of Australia's climate policy

- **One-third of global coal exports come from Australia**, accounting for 7% of global carbon emissions.
- The country is the largest **exporter of coal** and liquefied natural gas in the world.
- Australian government has defended the country's coal industry despite criticism from environmentalists.
- Australia has also invited criticism for counting carbon credits under the Kyoto Protocol instead of making new reductions to meet its emissions targets.

27.3.2. Wildfires and Zombie Fires Have Reached the Tundra Region

- Wildfires on **permafrost in Siberia** south of the Arctic are **not uncommon**.
- But in 2020, burning occurred well above the Arctic Circle (tundra), a region **not normally known to support large wildfires**.
- It is because of the unprecedented drying up of the tundra vegetation like moss, grass & dwarf shrubs.
- Also, the 'zombie fires' are becoming more frequent in the once-frozen tundra — north of the Arctic Circle.
- A **zombie fire (holdover fires)** is a **fire from a previous growing season** that can smoulder (burn slowly with smoke but no flame) under the ground which is made up of **carbon-rich peat**.

Concerns

- The fires & record temperatures have the **potential of turning the carbon sink into a carbon source**.

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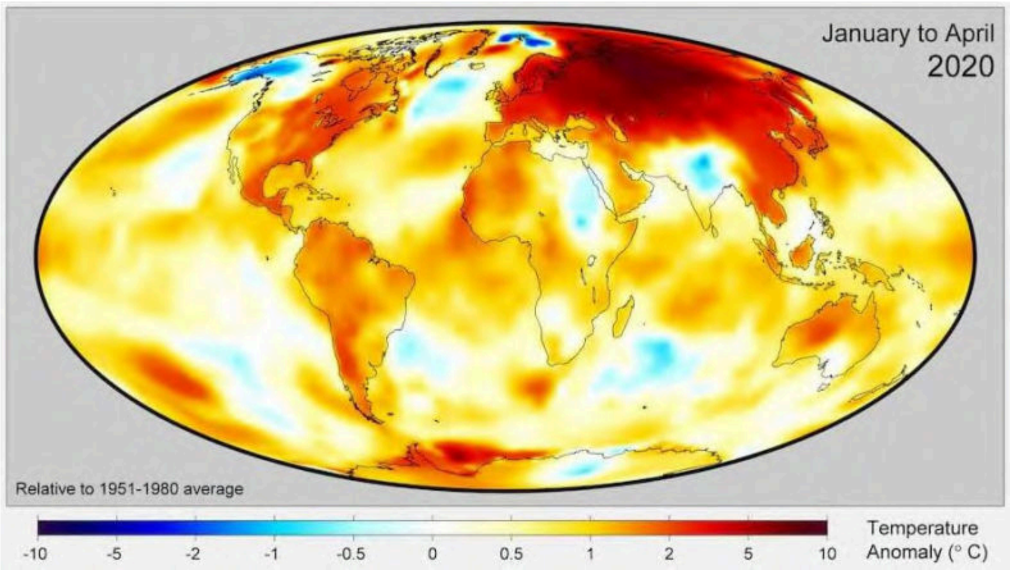

27.4. Shrinking Cryosphere

- The areas of snow or ice, which are subject to **temperatures below 0 °C (32 °F) for at least part of the year**, compose the cryosphere.
- **Continental ice sheets** found in Greenland and Antarctica, ice caps, glaciers, and areas of snow (glaciers of Alps, Himalayas) and **permafrost (Siberia)**, frozen parts of the ocean, rivers, and lakes, etc. are all part of the cryosphere.
- Glaciers from almost half of natural World Heritage sites — such as the **Khumbu Glacier in the Himalayas** — may disappear completely by 2100, if emissions continue at current rate, a IUCN study warns.
- The study predicts glacier extinction in 21 of the 46 natural World Heritage sites with glaciers.

Role of Cryosphere

- **Snow and ice (have highest albedo)** reflect heat from the sun (heat budget).
- Glaciers and high snow-covered mountains supply freshwater to many parts of the world.
- Cryosphere is **most sensitive to climate shifts** and hence it acts as **earth's black box** (ice accumulates layer over layer. **Studying the vertical ice column helps understand past global changes in climate**).

27.4.2. Consequences of Shrinking Cryosphere (Glaciers)

- Water scarcity and water wars between nations.
- Loss of ecologically rich and important **coastal wetlands**.
- **Distress migration** of coastal inhabitants due to submergence of major coastal cities.
- Submergence of **Small Island Developing States** (first to suffer the consequences of climate change).
- Disastrous changes in major weather patterns.
- As a result of thawing of snow, the **amount of arable land in high-latitude region is likely to increase** by reduction of the amount of frozen lands.
- At the same time **arable land along the coast lines are bound to be reduced** as a result of rising sea level and **saline water inundations**.
- Groundwater resources of the coastal regions will also be severely affected by salinization.
- Reduced hydroelectric power generation due to abnormal behaviour of glaciers will further increase dependence on fossil fuels.
- Widespread vanishing of animal populations due to habitat loss will add more species to the 'threatened' and 'extinct' list.

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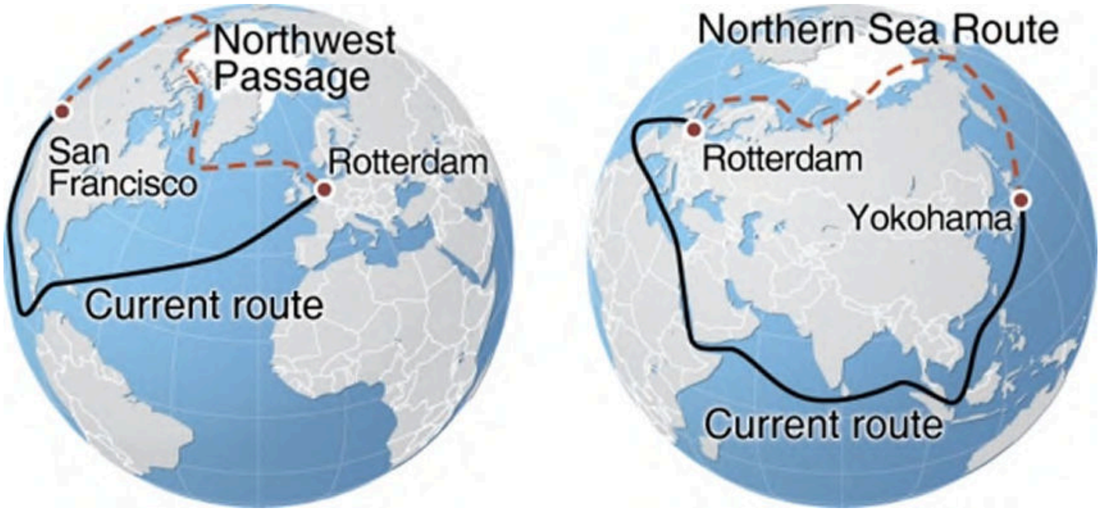
Surge-Type Glaciers and Disasters

- Surge-type glaciers are glaciers that have shown advancement in volume and length over a period.
- Such glaciers go against the normal trend of considerable reduction in volume and length of most glaciers.
- Surging glaciers do not flow at a constant speed, rather are subjected to cyclical flow instabilities.
- These types of glaciers can give rise to catastrophic **glacial lake outburst** floods when they break due to **global warming**.

27.4.3. New Sea Routes in The Arctic region

- The **Arctic Region is warming up twice as fast as the global average**.
- The **Northern Sea Route (NSR)** which would connect the **North Atlantic** to the **North Pacific** through a short polar arc is slowly opening due to the melting of ice.
- Models predict that this route could be ice free in summer by 2050.



- The loss of ice & the warming waters will affect sea levels, salinity levels, & current precipitation patterns.
- The **tundra is returning to swamp (→ loss of forest → loss of carbon sink)**, the **permafrost is thawing (→ exposing the subsurface carbon sinks)**, & wildfires are devastating interior Canada & Russia.

New Opportunities

- The opening of the Arctic presents **huge commercial & economic opportunities**, particularly in shipping, energy, fisheries, & mineral resources.
- Commercial navigation through the NSR is the most tempting: The distance from Rotterdam to Yokohama will be cut by 40 per cent compared to the Suez route.
- Access to unexploited resources:
  - ✓ Unexplored oil & natural gas deposits are estimated to be **22% of the world's unexplored resources**, mostly in the **Arctic Ocean** (**Barents Sea Region**)
  - ✓ mineral deposits including **25 per cent** of the **global reserves of rare earths** are buried in **Greenland**.

Challenges associated with the new opportunities

- Mining & deep-sea drilling carry massive costs & **environmental risks**.
- The complication is that, **unlike Antarctica, the Arctic is not a global common**.
- There is **no treaty that governs it**, only the **UN Convention of Law of the Sea (UNCLOS)** deals it.

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- Large parts of it are under the sovereignty of the five littoral states — **Russia, Canada, Norway, Denmark (Greenland)** & the **US** & exploitation of the new resources is well within their rights and can trigger **fresh territorial conflicts**.

Q. How does the cryosphere affect global climate? (2017)
Q. Why is India taking keen interest in resources of Arctic Region? (2018)
Q. What is the economic significance of discovery of oil in the Arctic Sea & its possible environmental consequences? (2015)

27.5. Sea Level Change

- Sea level change means the fluctuations in the mean sea level over a considerably long period of time.

27.5.1. Processes that cause Change in Sea Level

1. **Eustatic changes** occur when the volume of sea water changes due to factors such as
   - ✓ **global warming and melting of ice sheets** (rise in sea level) or ice ages (fall in sea level) and
   - ✓ changes in the volume of mid-oceanic ridges.
2. **Tectonic changes** occur due to a change in land level
   - ✓ Isostatic changes take place due to **addition or removal of load**: during ice ages, landmass subsided due to the load exerted by the glacial ice. On the other hand, **landmasses rise as the glacial ice is removed**.
   - ✓ Epeirogenic movement occurs due to broad scale tilting of continents which may result in the rise of one part of the continent even as the other part may subside causing an apparent rise in sea level.
   - ✓ Orogenic movement (mountain building) results in the formation of lofty mountains and an apparent fall in sea level.

27.5.2. Changes in Global Sea Level

- Commonly, seasonal variations of 5-6 cm in sea level are observed in a year.

Short-term sea level change due to a complex interaction of the following factors

- **Marine water density:** Temperature and salinity control the density of sea water. Low temperature and high salinity produce high density of sea water and lower sea level.
- **Atmospheric pressure:** Low pressure results in higher local sea level and vice versa. E.g., Storm surge.
- **Velocity of ocean currents:** Fast-flowing ocean currents when taking a curved path cause a rise in sea level on their outer fringes. Generally, a difference of 18 cm in sea level is observed between the two sides of a fast-flowing current.
- **Ice formation and fall in sea level:** During winter the ocean water trapped in the icecaps of the northern and the southern hemispheres leads to a fall in sea level.
- **Piling up of water along windward coasts:** A local rise of sea level occurs in the coastal region as water is driven towards the coasts by an air mass, for example, the sea level rises in south and east Asia during the monsoon months due to landward movement of the air mass.

Long-Term

- **Global warming** in the last century due to anthropogenic activities has resulted in **thermal expansion** of ocean water. So, the sea level has risen by about 10 to 15 cm in the past 100 years.
- **Melting of icesheets in the Antarctica** by about 3 per cent of its total volume of ice has, to some extent, contributed to global sea level rise.

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- Global sea level changes which exceed 100 m are possible only if the major ice-sheets melt or there are substantial changes in the volume of the world's mid-oceanic ridge.

27.5.3. Importance of understanding Sea Level Changes

- It provides key evidence regarding past climate change.
- It helps in estimating the rates of tectonic upliftment in the past geological periods.
- To assess the suitability of coastal locations for industrial and agricultural development.
- To protect low-lying countries by building coastal dykes and embankments.
- The task of mapping of areas likely to be affected by storm surges and periodic flooding becomes possible only if we know the likely areas to be affected by future sea level rise.
- By identifying the areas of possible submergence in the near future it becomes possible to set up tidal power generation plants in suitable locations.

27.5.4. Sea Level Rise and Coastal Flooding due to Global Warming

- World Meteorological Organization (WMO) has hinted at **global warming as a cause of current increase in sea surface temperatures** around the world.
- IPCC report warns sea level rise could reach **60 to 110 cm** if emissions continue to increase strongly.
- To check the phenomenon of sea level rise that the **'Oceans and Coastal Areas Programme Activity Centre'** was set up in 1987 under the aegis of the **United Nations Environment Programme (UNEP)** to identify the countries facing maximum risk of submergence.

IPCC: Extreme floods to increase economic loss 166 times in coastal megacities

- Economic losses due to extreme flooding will soar 166 times more by 2050, unless world's coastal megacities adapt to a climate change, warned a recent report by IPCC.
- India's financial capital, Mumbai, will also be among those bearing the brunt.
- More than half the global population live in cities, most of which are located in low-lying islands and coasts.

A similar study says:

- **36 million** people along the Indian coastlines currently live on land that will fall below the annual flood level by 2050, exposing them to risks of flooding.
- 300 million people, and not 80 million as estimated earlier, across the globe were currently living in areas that were below the annual coastal flood line.
- Almost 80 per cent of these 300 million people live in China, Bangladesh, India, Vietnam, Indonesia and Thailand. China alone accounted for 43 million.

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- In each of several dozen major cities — including Bangkok, Hong Kong, Shanghai, Taizhou, Surabaya, Dhaka, **Mumbai**, Ho Chi Minh City and Osaka — millions will find themselves in flood zones.

27.5.5. Vulnerable areas in India

- **Bhuj, Jamnagar, Porbandar, Surat, Bharuch** and **Mumbai** are much more susceptible to rising sea levels.
- On the eastern side, almost the entire coastline of **West Bengal** and **Odisha** have been found under threat.

Q. 'Climate change' is a global problem. How India will be affected by climate change? How Himalayan and coastal states of India will be affected by climate change? (2017)

27.5.6. Regional Sea Level Rise (SLR)

- Globally, of the 68 per cent area that is prone to coastal flooding, over **32 per cent can be attributed to regional SLR**.
- **SLR is not uniform across the world**, so there is a need to differentiate regional SLR from the global rates.
- For instance, the **gravitational pull of the polar ice sheets** has different effects on sea levels in different parts of the world, which means regional SLR can be higher or lower than the global SLR.

How much of a threat is SLR?

- In 2019, Indonesia's President Joko Widodo announced that the country's capital would be relocated from **Jakarta** to the province of **East Kalimantan** on the **lesser populated island of Borneo**.
- The combination of climate change and heavy congestion continues to bury Jakarta, the **"world's fastest-sinking city", by about 25 cm into the ground every year.**
- The situation looks grim for India's financial capital **Mumbai** as well.
- As per some projections, climate change is expected to inundate significant sections of Mumbai by 2050.
- Cities that regularly feature in the lists endangered by climate change are **Guangzhou, Jakarta, Miami & Manila**.

What are some ways of protecting against SLR?

- Indonesia's government launched a coastal development project called a **Giant Sea Wall or "Giant Garuda"** (Garuda is the name of a bird from Hindu mythology and is Indonesia's national symbol) in 2014.
- **Northern European Enclosure Dam (NEED),** enclosing all of the **North Sea**, is a measure to protect 25 million people, and important European economic regions from rising seas as a result of CC.

- The idea involved construction of two dams of a combined length of 637 km to protect Northern Europe against "unstoppable" SLR.

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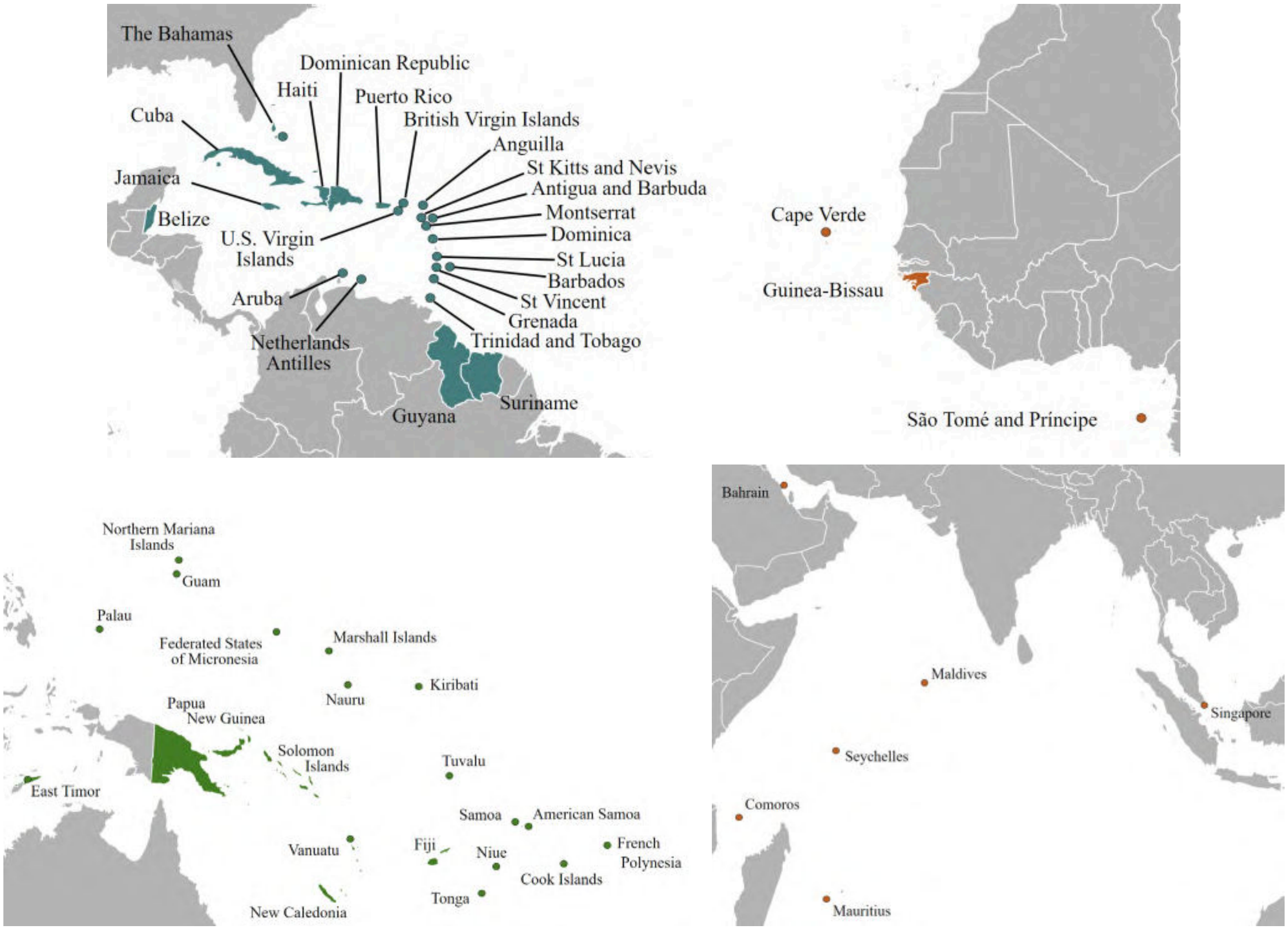
- It was identified that other regions such as the **Persian Gulf**, the **Mediterranean Sea**, the **Baltic Sea**, the **Irish Sea**, and the **Red Sea** that could benefit from similar mega enclosures.
- A Special Report on the Ocean and Cryosphere in a Changing Climate, published last year by the IPCC, noted that **"well-designed coastal protection"** could both "reduce expected damages" and "be cost efficient for urban and densely populated areas".

27.5.7. Small Island Developing States (SIDS) are the Biggest Losers

- Small Island Developing States (SIDS) are islands that are relatively **remote, vulnerable to environmental challenges, such as climate change**, and generally small in size.
- The SIDS were recognized as a distinct group of developing countries in June 1992, at the **UN Conference on Environment and Development (1992 Earth Summit)**.
- Most of the SIDS are **coral islands formed on shallow atolls**. Hence, they are **highly vulnerable to sea level rise**.
  - ⇨ *In 2016, the **Marshall Islands** sued India, Pakistan and Britain in the International Court of Justice for **failing to halt the nuclear arms race**.*



Small Island Developing States | Maps from Wikipedia

Barbados Programme of Action (1994)

- **United Nations Programme of Action** on the **Sustainable Development of Small Island Developing States** is popularly referred to as the **Barbados Program of Action (BPOA)**.
- It is a policy document that addresses the economic, environmental and social developmental **vulnerabilities facing islands** & outlines a strategy that seeks to mitigate those vulnerabilities.

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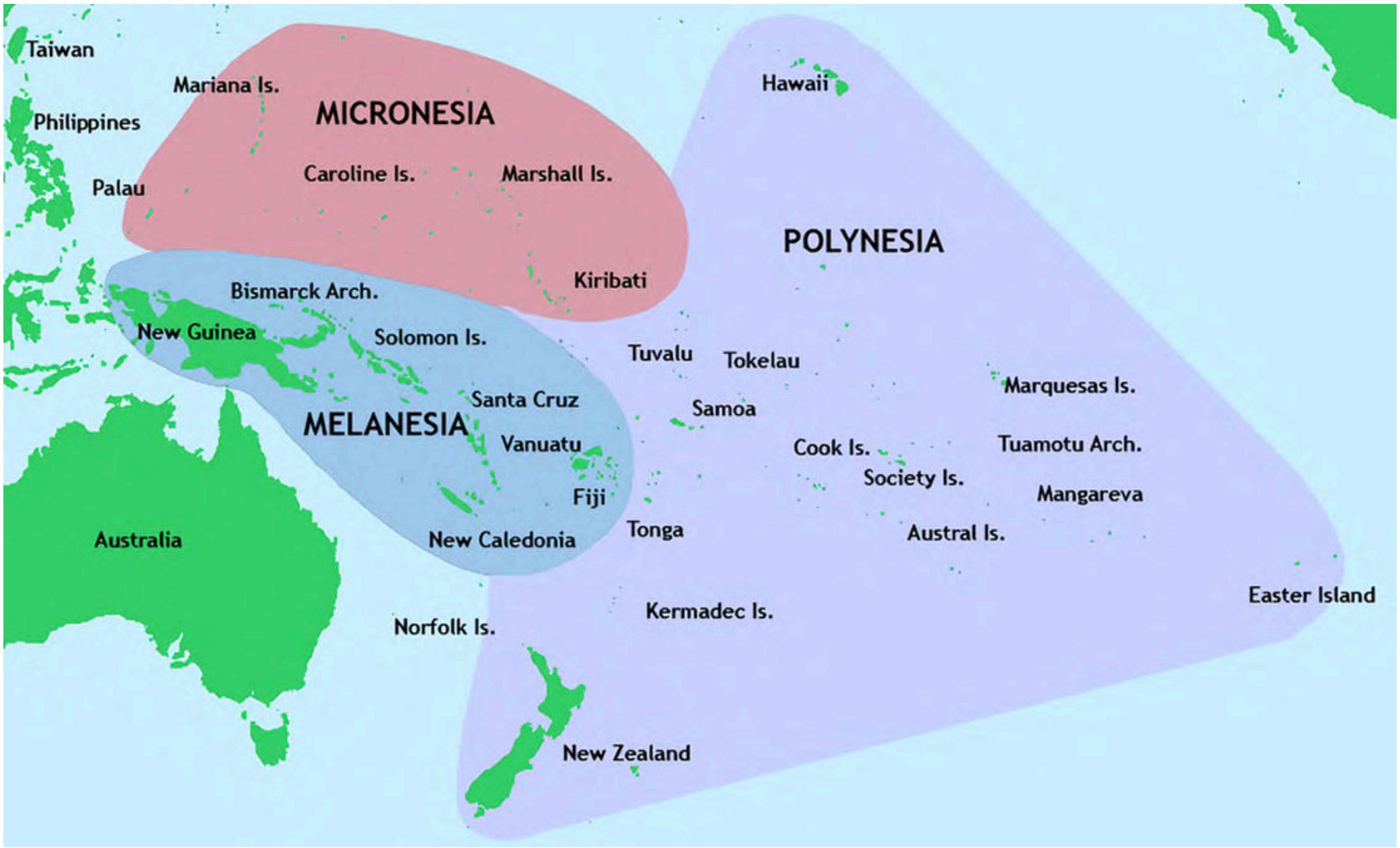
- It remains the **only** internationally approved programme specific to Small Island Developing States (SIDS).

Mauritius Strategy (2005)

- It is a 10-year comprehensive review of the Barbados Programme of Action (BPOA).
- The outcome was the adoption of the **Mauritius Strategy** for the further Implementation of the **BPOA.**



27.6. Tropical Cyclones are Becoming More Severe

- Tropical cyclones require a sea surface temperature of **26.5°C** to form, while the highest intensity storms require much warmer sea surface temperatures of 28-29°C.
- The frequent high intensity storms have been tied to the **very warm sea surface temperatures (30°C+).**

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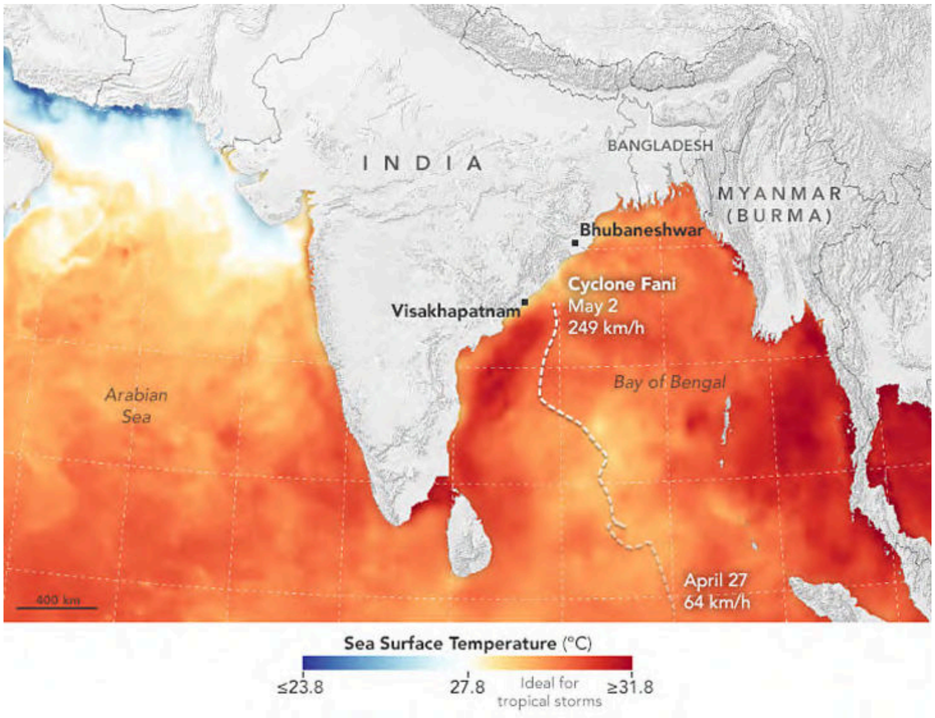

- The South Indian Ocean that previously experienced the temperatures of 26.5°C is now experiencing temperatures as warm as 30-32°C.
- The increasing ocean temperatures gave rise to devastating **Idai cyclone in March 2019** (1300+ causalities) in the South-West Indian Ocean basin (South-East Africa).
- Regions further from the equator are more regularly experiencing the threshold temperature or 24-26°C **widening the range of formation of tropical cyclones**.
- These conditions are exacerbated by global forcing mechanisms including El Niño, Indian Ocean Dipole**, Southern Annular Mode** and **Madden-Julian Oscillation** (these in turn are affected by global warming).

27.6.1. Unusual Timing & High Frequency

- **Extremely Severe Cyclonic Storm Fani (April 2019)** is India's **strongest April cyclone in 43 years**.
- The unusual timing (April) is attributed to **global warming** (unusual warming of the Bay of Bengal).
- The severe cyclone frequency in the north Indian Ocean has registered about a three-fold increase.
- About one severe cyclone was expected to form every year during the intense cyclonic period (May, October and November), the number has now gone up to about **three per year**.

27.6.2. The number and intensity of tropical cyclones is increasing in the Arabian Sea

- Almost 50% of the storms do not sustain over the Arabian Sea since the west-central and north Arabian Sea (due to **Findlater/Somali Current that causes local upwelling**) have a relatively colder sea temperature.
- This cold sea surface temperature is not favourable for the development and sustenance of cyclonic storms.
- However, this is changing. The Arabian Sea is heating rapidly and **driving more cyclones**, and **excessive rainfall (excessive rainfall in sea ➔ less moisture in monsoon winds ➔ less rainfall on mainland)**.
- Climate models suggest that 64 per cent of the cyclone risk in the Arabian Sea was due to climate change.

Increased occurrence of Severe cyclonic storms

- In the usual course, there was an occurrence of one extremely severe cyclone in every four-five years.

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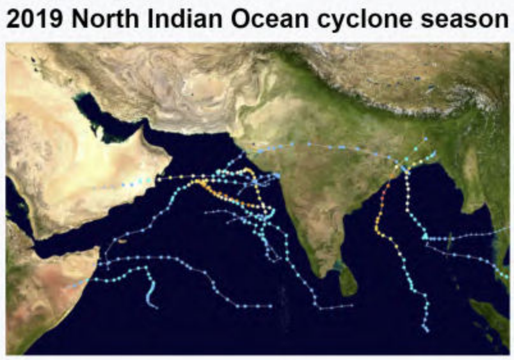
- Now the Arabian Sea started receiving tropical cyclones of high intensity in a small-time interval. For instance, in 15 years (1998 to 2013), five extremely severe cyclones originated in the Sea.



Unusual timing

- In 2019, a Very Severe Cyclonic Storm Vayu occurred in the Arabian Sea in the month of June.
- This is unusual as the **conditions in June are not conducive for the depressions to turn into severe cyclones (due to the outbreak of monsoons)**.

Changing path

- Previously, tropical cyclones in the Arabian Sea were **restricted to Gujarat**.
- In the past decade though, **Kerala** and **Karnataka** have also become more vulnerable to cyclones.

Mains Practise: What are the consequences of Global Warming (anthropogenic impact) on the Indian weather conditions?

- Answer must include El Nino, Tropical Cyclones, Hotter summers – devastating heat waves.
- Include examples like 2018 Kerala floods, 2015 Chennai Floods, Severe Cyclonic Storm Fani, etc.

27.7. Deterioration of Carbon sinks

- **High latitude forests store more carbon than tropical rainforests**.
- **One third of the world's soil-bound carbon is in taiga and tundra areas**.
- **When the permafrost melts due to global warming, it releases carbon in the form of carbon dioxide and methane**.
- In the 1970s the tundra was a carbon sink, but today, it is a **carbon source**, all because of global warming. (**Global warming leads to more global warming ➔ positive feedback loop**).

27.7.1. Carbon Dioxide Fertilization

- Earth's vegetated lands have shown significant **greening** largely due **to rising levels of atmospheric CO_2**.
- Greening means an **increase in leaves on plants and trees**. Increased concentrations of CO_2 **increases photosynthesis**, spurring plant growth.

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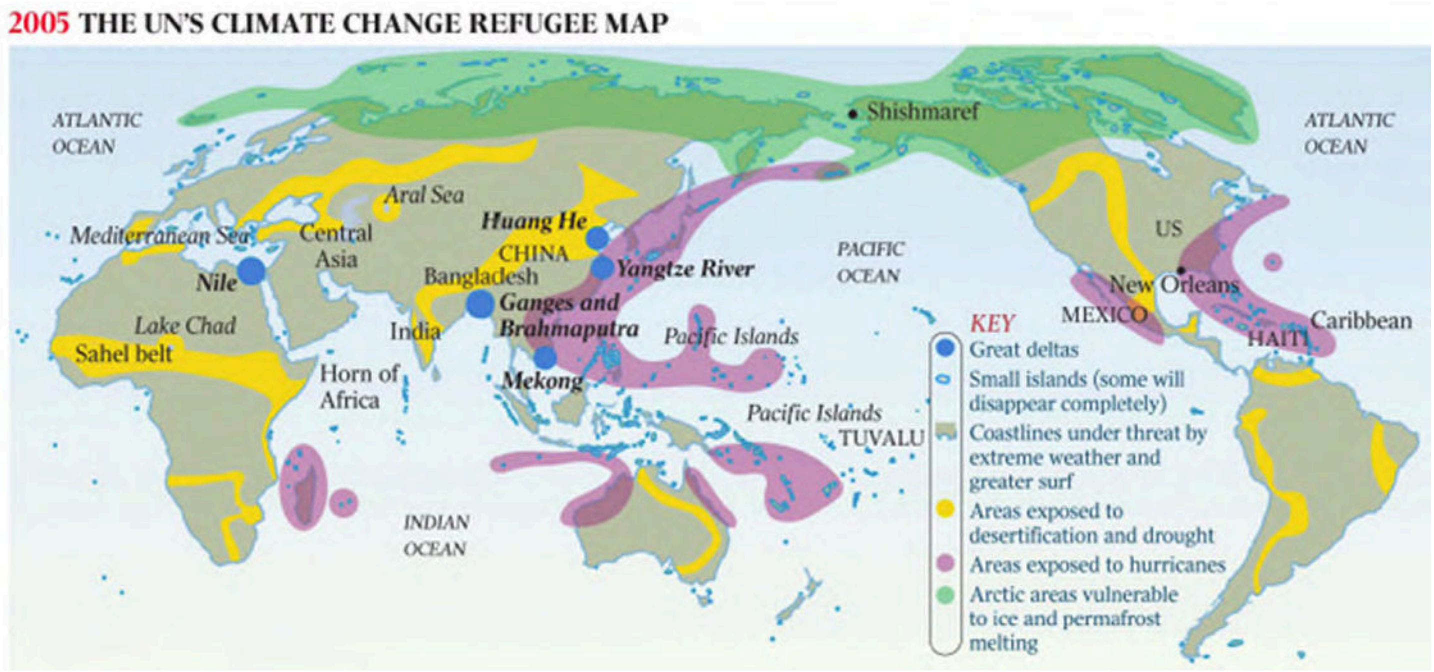

- **Carbon dioxide** fertilization contributes to **70 percent of the greening effect**. The second most important driver is **nitrogen**, at 9 percent.
- The rest occurs due to land cover changes, climate change, precipitation, and sunlight changes.
- Plants acclimatize to rising CO_2 concentration and the **fertilization effect diminishes over time**.
- That is, raising CO_2 concentrations may be **beneficial for plants in the short run**, but in the long run it is harmful due to climate change.

27.7.2. Carbon Dioxide Fertilization is increasing carbon sink on land

- Every year, about half of the 10 billion tons of carbon emitted into the atmosphere from human activities remains **temporarily stored**, in about **equal parts**, in the **oceans and plants**.
- Studies have reported an **increasing carbon sink on land** since the 1980s, which is entirely consistent with the idea of a **greening Earth**.

Q. Which of the following statements best describes "carbon fertilization"? (2018)

a) Increased plant growth due to increased concentration of carbon dioxide in the atmosphere
b) Increased temperature of Earth due to increased concentration of carbon dioxide in the atmosphere
c) Increased acidity of oceans as a result of increased concentration of carbon dioxide in the atmosphere
d) Adaptation of all living beings on Earth to the climate change brought about by the increased concentration of carbon dioxide in the atmosphere

Answer: a)

27.8. Climate Migrants

- National Sample Survey Office (NSSO) 2007-08 report titled Migration in India identified natural disasters as one of the major reasons for migration (13/1,000 migrants).
- **Environmental Migrants:** people displaced due to adverse changes to their local environment.
- **Climate migrants:** migrants due to climate change impacts such as **sea level rise (Sundarbans)**, **floods (Ganges, Brahmaputra basins), drought (central India, Vidarbha, Telangana, Rayalaseema)**, etc.

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- Displacement or rise in migration due to disasters has raised concerns on increasing human trafficking, conflicts and pressure on resources.

27.8.1. World Risk Index (WRI) 2020

- India was 'poorly prepared' to deal with 'climate reality', due to which it was more vulnerable to extreme natural disasters, according to the **World Risk Index (WRI) 2020**.
- **India ranked 89th among 181 countries on the WRI 2020**.
- **The country was 4th-most-at-risk in south Asia** on the index, after Bangladesh, Afghanistan & Pakistan.
- Sri Lanka, Bhutan and the Maldives fared better than India in their abilities to cope with extreme disasters.
- The report identified **Africa as a hotspot of vulnerability**.
- The **Central African Republic** was the most vulnerable country, followed by Chad, the Democratic Republic of Congo, Niger and Guinea-Bissau.

High And Low Risk Nations

- The index showed that **Oceania (Small Island Developing States (SIDS) are a part of Oceania)** was the continent most at risk, followed by Africa and the Americas.
- **Vanuatu** was the country with the **highest disaster risk** worldwide.
- It was followed by **Tonga** and **Dominica**.
- **Qatar** had the lowest risk (0.31) according to the global index.

27.9. Other Impacts

27.9.1. Economic Losses

- Economic losses suffered involve money spent on
  - ✓ adaptation to climate change (costs involved in moving from submerging areas to higher ground),
  - ✓ rebuilding post extreme climatic event and
  - ✓ money spent on climate change mitigation (like carbon sequestration).
- The **economic losses suffered** due to the **emission of one ton of carbon dioxide into the atmosphere** is termed **social cost of carbon**. It is expressed as the dollar value of the loses suffered.
- **India's country-level social cost of carbon emission** was estimated to be the **highest at $86 per tonne of CO_2**.
- It means the Indian economy will lose $86 by emitting each additional tonne of CO_2.
- India is followed by the US, where the economic damages would be $48 per tonne of CO2 emission.

Q. Which one of the following statements best describes the term 'Social Cost of Carbon'? It is a measure, in monetary value, of the (2020)

a) long-term damage done by a tonne of CO2 emissions in a given year.
b) requirement of fossil fuels for a country to provide goods and services to its citizens, based on the burning of those fuels.
c) efforts put in by a climate refugee to adapt to live in a new place.
d) contribution of an individual person to the carbon footprint on the planet Earth.

Answer: a)

27.9.2. Ocean Deoxygenation

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- Ocean deoxygenation is the expansion of **oxygen minimum zones (OMZs)** in the world's oceans as a consequence of anthropogenic emissions of carbon dioxide.
- OMZs are found in areas where an interplay of physical (**ocean stratification**) and biological (**less photosynthesis**) processes create a "pool" of water where oxygen concentrations fall (**anoxic zones**).
- Warmer oceans cause deoxygenation both **because oxygen is less soluble in warmer water**, and through temperature driven stratification.

Effects of deoxygenation of oceans

- As oceans lose oxygen, they become more acidic resulting in shellfish having their shells degraded.
- Reduction in cycling of elements such as carbon, nitrogen & phosphorous which are essential for lifeforms.
- Dying of fish in large numbers due to less phytoplankton to feed on.

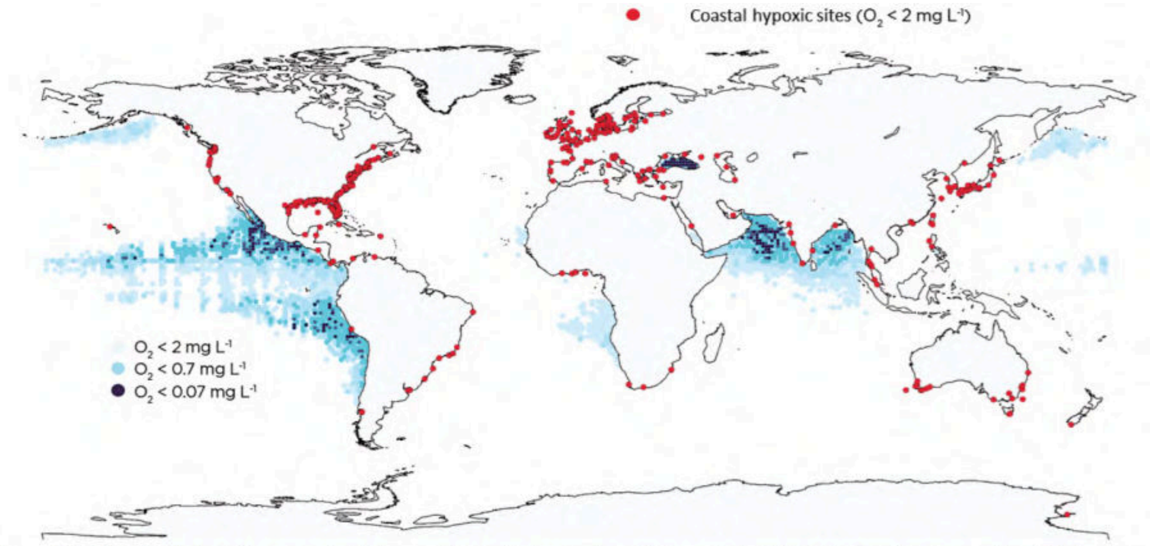

Figure 1.3 Global distribution of deoxygenation in the coastal and global ocean (from Breitburg et al., 2018). In the coastal area, more than 500 sites have been inventoried with low oxygen conditions while in the open ocean the extent of low oxygen waters amounts to several millions km^3.

27.9.3. Biodiversity Loss

- **Loss of Plankton** due to warming of seas will adversely affects marine food chain.
- **Bleaching of Coral Reefs** (rain forests of the ocean) will cause great loss of marine biodiversity.
- Rising temperature would increase fertilizer requirement for the same production targets and result in **higher GHG emissions, ammonia volatilization** and cost of crop production.
- Rising temperatures will further affect the physical, chemical and biological properties of fresh water lakes and rivers, with adverse impacts on many individual fresh water species.

27.9.4. Food and Health Security at Risk

- Climate Change affects crops by impacting irrigation, insolation as well as the prevalence of pests.
- Increased frequencies of droughts, floods, storms and cyclones are likely to increase agricultural production variability.
- Moderate warming (increase of 1 to 3°C in mean temperature) is expected to **benefit crop yields in temperate regions**, while in lower latitudes the crops will take a hit.
- However, the natural calamities due to global warming can offset the benefits in temperature regions.
- Spread of diseases (like malaria, etc.) in tropics will put more pressure on the health care sector.
- Lack of freshwater during droughts and contamination of freshwater supplies during floods compromise hygiene, thus increasing rates diseases like cholera, diarrhoea etc.

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28. Climate Change Mitigation

28.1. Clean coal technology to reduce CO_2 Emissions

- Half of the world's electricity is generated by burning coal and coal will remain a dominant energy source for years to come.
- **CO_2** and **CO (carbon monoxide)**, **nitrogen oxides (destroys ozone)** and **sulphur oxides (acid rains)** are the major greenhouse gas which are released during burning of coal.
- Clean coal technology seeks to reduce harsh environmental effects by using multiple technologies.
- Some clean coal technologies **purify the coal before it burns**.
- Coal preparation, coal washing, **removes unwanted minerals** by mixing crushed coal with a liquid and allowing the impurities to separate and settle.
- Other systems control the coal burn to minimize sulphur dioxide, nitrogen oxides and particulate emissions.
- **Electrostatic precipitators** remove particulates by charging particles with an electrical field and then capturing them on collection plates.
- **Coal Gasification avoids burning coal altogether**. With gasification, steam and hot pressurized air or oxygen combine with coal in a reaction that forces carbon molecules apart.
- The resulting **syngas**, **a mixture of carbon monoxide** and **hydrogen**, is then cleaned and burned in a gas turbine to make electricity.
- **Wet scrubbers**, or **flue gas desulfurization** systems, remove **sulphur dioxide** by spraying flue gas with **limestone** and water.
- Low-NO_x (nitrogen oxides) burners reduce the creation of nitrogen oxides by restricting oxygen and manipulating the combustion process.

28.1.1. India's coal

- Coal mined in India is a poor-quality coal (India's coal is **not Carboniferous Coal**. It is **Gondwana coal**) with **less carbon, high ash** (hard to dispose) and **high moisture content** (more gases; less fuel efficiency) .
- To improve efficiency and reduce adverse effects, India should do away with its present sub-critical coal power plants and build more **super-critical and ultra-super-critical ones** (15-20% increase in efficiency).

28.2. Carbon capture and storage

- 'Carbon capture and storage' catches and **sequesters (hide) carbon dioxide (CO_2)** from stationary sources like power plants.
- Capture: **Flue-gas separation** removes CO_2 and condenses it into a concentrated CO_2 stream.
- After capture, secure containers sequester the collected CO_2 to prevent its re-entry into the atmosphere.
- The two storage options are **geologic** and **oceanic** (must hide the CO_2 until peak emissions subside hundreds of years from now). Geologic storage involves injecting CO_2 into the earth
- **Depleted oil or gas fields** and **deep saline aquifers safely** store CO_2 while **coal seams** absorb it.
- **Ocean storage**, a technology still in its early stages, involves injecting liquid CO_2 into waters 500 to 3,000 meters deep, where it **dissolves under pressure**.
- However, this method would slightly **decrease pH (acidification) and potentially harm marine habitats**.

28.3. Carbon Sink and Carbon Sequestration

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- A **carbon sink** is a **natural or artificial reservoir** that **accumulates and stores some carbon-containing chemical compound for an indefinite period**.
- The process by which **carbon sinks remove carbon dioxide (CO_2)** from the atmosphere is known as **carbon sequestration**.
- Carbon sinks help to tackle the challenge of climate emergency.
- **Natural carbon sinks** include **forests, soil** and **oceans**.
- Unlike other natural sinks, **ocean uptake of carbon dioxide results in acidification** threatening species like corals.

28.3.1. Carbon Sink vs Carbon Source

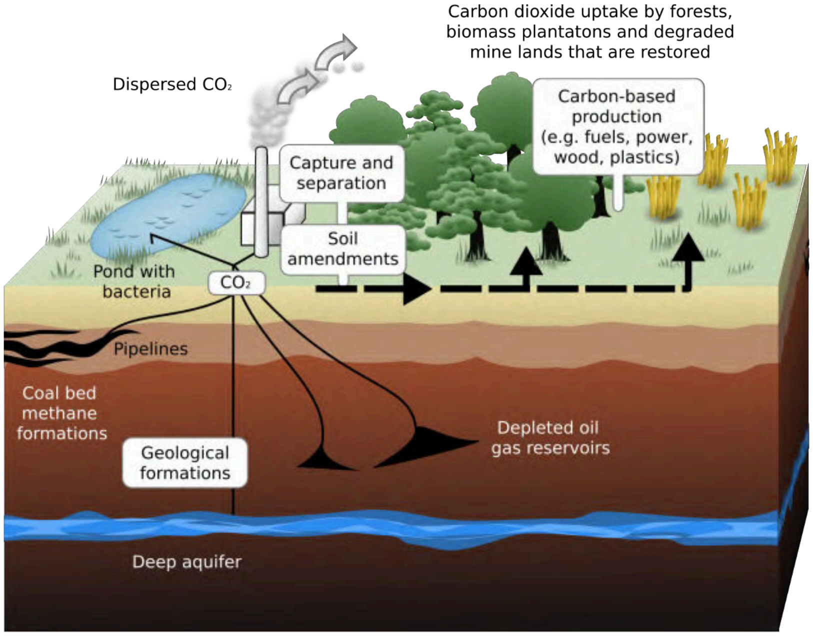
- A carbon sink is **anything that absorbs more carbon than that it releases**, whilst a **carbon source is anything that releases more carbon than is absorbs**.
- **Forests, soils, oceans** and the **atmosphere** all store carbon, and this carbon moves between them in a continuous cycle (carbon cycle).
- This constant movement of carbon means that **forests act as sources or sinks at different times**.

28.3.2. Carbon sequestration

- Carbon sequestration is the **process of capture and long-term storage of atmospheric carbon dioxide**.
- It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases.
- Carbon dioxide is **naturally captured** from the atmosphere through biological, chemical, or physical processes.

28.3.3. Forests as carbon Sinks

- Forests are **carbon stores**, and they are **carbon dioxide sinks** when they are increasing in density or area.
- Trees **absorb CO_2 during photosynthesis** thereby converting **atmospheric CO_2 into biomass**.
- When this biomass is buried, the **carbon is trapped forming a carbon sink**.
- When the carbon sink is exposed, the **biomass decomposes** adding **methane** to the atmosphere.
- When the **biomass is used as fuel** (coal, petroleum) it **releases CO_2** into the atmosphere **(carbon source)**.



28.3.4. Oceans as Carbon Sink

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- Ocean is also a very important **carbo sink**. **Most of the carbon (and methane) is trapped in the ocean** and if a small fraction of this carbon is released the consequences will be **disastrous**.

Q. In the context of mitigating the impending global warming due to anthropogenic emissions of carbon dioxide, which of the following can be the potential sites for carbon sequestration?

1) Abandoned and uneconomic coal seams
2) Depleted oil and gas reservoirs
3) Subterranean deep saline formations

Select the correct answer using the code given below:

a) 1 and 2 only
b) 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- From figure it is clear that **abandoned coal seems, depleted oil** and **gas reservoirs** can be used for carbon sequestration.

Answer: d) all

Q. The scientific view is that the increase in global temperature should not exceed 2 °C above pre-industrial level. If the global temperature increases beyond 3°C above the pre-industrial level, what can be its possible impact/impacts on the world?

1) Terrestrial biosphere tends toward a net carbon source
2) Widespread coral mortality will occur.
3) All the global wetlands will permanently disappear.
4) Cultivation of cereals will not be possible anywhere in the world.

Select the correct answer using the code given below.

a) 1 only
b) 1 and 2 only
c) 2, 3 and 4 only
d) 1, 2, 3 and 4

Explanation:

- **Taiga and temperate forests act as an important carbon sink**. **Global warming by 3 °C will turn these forests into carbon source (because of thawing of permafrost and wildfires).**
- **Corals are overly sensitive to temperature changes.** 3 °C rise in global temperature will lead to widespread coral mortality.
- 3° C rise in global temperature will lead to submergence of many low-lying coastal wetlands like **Sundarbans, Chilika Lake**, etc. due to rise in sea levels.
- Inland wetlands like **Keoladeo Ghana National Park, Kolleru Lake, etc.** will not be affected.
- It has been estimated that a sea-level rise of approximately 2.3 metres for each degree Celsius of temperature can occur within the next 2,000 years.
- Cultivation of cereals in tropics will take a hit. But in temperate regions **their production increases** in the short run.

Answer: b) 1 and 2 only

28.4. Geoengineering to Fight Climate Change

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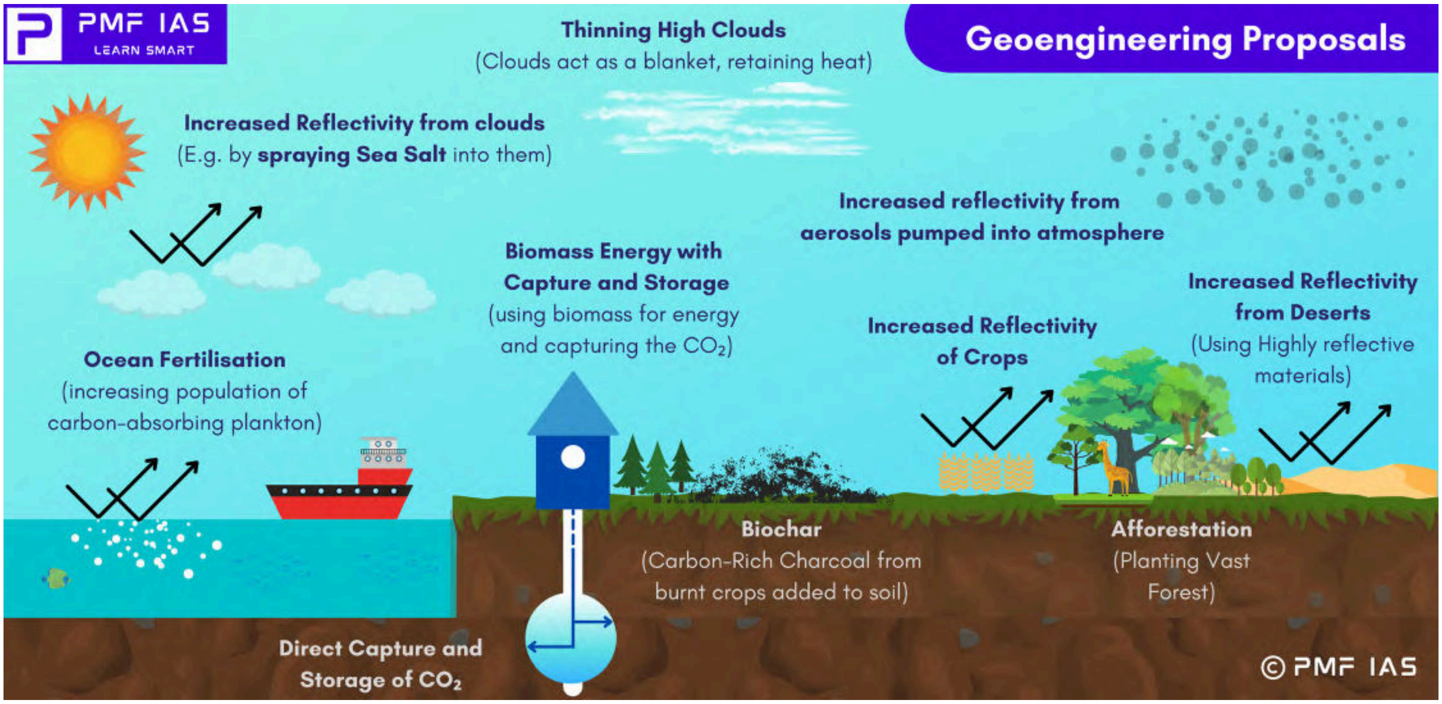
- The Oxford Geoengineering Programme defines geoengineering as "**the deliberate large-scale intervention in the Earth's natural systems to counteract climate change**".
- Geoengineering technologies include **managing solar radiation**, **removing carbon dioxide and other GHGs from the atmosphere, afforestation, protecting the cryosphere on a large scale**, etc.

28.4.1. Solar Radiation Management (SRM) or Solar Geoengineering

- SRM techniques aim to **reflect a small proportion of the Sun's energy back into space**.
- **Albedo enhancement:** **Increasing the reflectiveness of clouds** or the land surface.
- **Space reflectors:** Blocking a small proportion of sunlight before it reaches the Earth.



- **Stratospheric aerosols:** Introducing small, reflective particles into the upper atmosphere to reflect some sunlight before it reaches the surface of the Earth.

Q. In the context of which of the following do some scientists suggest the use of cirrus cloud thinning technique and the injection of sulphate aerosol into stratosphere? (2019)

a) Creating the artificial rains in some regions
b) Reducing the frequency and intensity of tropical cyclones
c) Reducing the adverse effects of solar wind on the Earth
d) Reducing the global warming

Explanation:

- Creating the artificial rains in some regions ➔ **Cloud Seeding**
- Reducing the frequency and intensity of tropical cyclones ➔ **Sea Surface Temperature** should be reduced for this. Mitigating climate change is the solution.
- Reducing the adverse effects of solar wind on the Earth ➔ Earth's Magnetosphere will take care of this.
- Do you know why **Venus is the brightest planet in the solar system**? It is because of the thick dense atmosphere and thick clouds composed mainly of **highly reflective sulfuric acid droplets**.
- These clouds reflect about 75% of the sunlight (**high albedo**) that falls on them. This makes optical imaging of the surface of Venus a very tough job.

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- **Injection of sulphate aerosol ➔ will increase the albedo of the atmosphere**.
- Very thin, high clouds such as **cirrus clouds reflect little sunlight**, they are very **efficient at absorbing thermal radiation (heat)**, **making them "strong warmers"**.
- **Cirrus cloud thinning ➔ will absorb less thermal radiation reflected by earth**.

Answer: d) reducing the global warming

28.4.2. Greenhouse Gas Removal (GGR) or Carbon Geoengineering

- GGR techniques aim to directly remove carbon dioxide or other greenhouse gases from the atmosphere.
- **Afforestation:** Engaging in a global-scale tree planting effort.
- **Biochar:** 'Charring' biomass and burying it so that its **carbon is locked up in the soil**.
- **Bio-energy with** carbon capture and sequestration**:** Growing biomass, burning it to create energy and capturing and sequestering the carbon dioxide created in the process.
- **Ambient Air Capture:** Building large machines that can remove carbon dioxide directly from ambient air (helps only if they are **carbon negative** ➔ more carbon is absorbed than released).
- **Ocean Fertilisation:** Adding nutrients to the ocean in selected locations to **increase primary production**.
- **Enhanced Weathering:** Exposing large quantities of minerals that will react with carbon dioxide in the atmosphere and storing the resulting compound in the ocean or soil.

28.4.3. Forests for Carbon Geoengineering

- In boreal forests as much as **80% of the total carbon** is stored in the **soils** as **dead organic matter (peat)**.
- Tropical forests absorb about 18% of all carbon dioxide added by fossil fuels.
- A lot of emphasis and hope has been put into the **ability of trees**, other plants and the **soil** to **temporarily sink the carbon** that **fossil fuel burning** releases into the atmosphere.
- Indeed, the **Kyoto Protocol**, the international communities' main instrument for halting global warming suggests that the **absorption of carbon dioxide by trees and the soil is just as valid a means to achieve emission reduction commitments as cutting carbon dioxide emissions from fossil fuels**.

28.4.4. Artificial snow

- Due to global warming, the West Antarctic Ice Sheet is expected to get disintegrated from the Antarctic.
- The melting of the disintegrated sheet would trigger global sea level rise of **at least 3 metres over centuries**.
- Last-ditch geoengineering project proposed to prevent disintegration is to blanket its surface with **artificial snow**.
- It involves using thousands of wind turbines to pump seawater 1,500 metres up to the surface, where it would be frozen into "snow" to try to weigh the sheet down enough to stop it collapsing any further.

28.5. Transition Away from Coal

- IPCC established that a 1.5 °C-consistent trajectory **requires coal-powered electricity to drop to less than one per cent of the total electricity mix by 2050**.
- One proposal is to phase out the oldest coal plants first. This would phase out coal in developed (most of the coal power plants are old) and developing (some of the coal power plants are new and many are under construction) economies at a differentiated rate.

28.5.1. Current phaseout efforts

- The UK plans to shut down all "unabated" coal-fired electricity by 2025.

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- France and Italy have also made similar political commitments.
- Germany finalised a plan to shut down all coal power plants by 2038.
- There is an international coalition coordinating on the coal phase-out problem — the **"Powering Past Coal" Alliance** (currently not a formal organisation), announced at UNFCCC COP23 in Bonn.
- The Alliance is based on a commitment to phasing out coal in the **OECD (by 2030) & globally (by 2050)**.
- These political actions **miss the largest consumers of coal** — the **US, Japan, China, India** — and significant exporters such as **Australia, Indonesia, Russia and South Africa**.
- Worse, current phase-out plans, such as Germany's, fall short of the ambition required to stay within 2 °C.
- Also, over the next 20 years, coal going offline in Europe and OECD countries is off-set by **increases in consumption in Africa & Asia, particularly India**.
- Global coal consumption hence **increases by five per cent between 2010 and 2040**.
- **Coal consumption in India is said to increase by 29 per cent until 2040 !!**

28.5.2. Barriers to Phasing Out Coal Power

- The barriers to the transition are economic and political rather than technological.
- They generally take 4 forms — stranded assets, livelihood loss, electricity prices, and irresponsible financing.

Livelihood impacts

- In India, around one million livelihoods depend directly or indirectly on coal power.
- **Coal royalties** constitutes almost **50 per cent of total earnings of states like Jharkhand and Odisha**.
- China employs about five million in coal industries.
- Most workers in China's coal sector are off-farm workers who have very limited job choice.
- In **Australia**, around 50,000 are employed in coal mining, representing 0.4 per cent of the direct workforce.
- Coal workers are generally older. This limits the capacity for re-skilling.

Stranded assets

- Since 2006, India has added 151 GW of new coal power, with about **75 per cent of this capacity being subcritical**. The present value of these assets is around **$100 billion**.
- A similar problem exists in China, with electricity policy resulting in an **over-supply** of coal power capacity.
- Coal power capacity is less of a problem in **Europe & US**, since coal plants are closer to the end of their life.
- Coal accounted for about **15 per cent of Australia's total export value** in 2017.
- **Indonesia** is the world's fifth largest producer of coal. Around 80 per cent of Indonesia's coal is exported.

Electricity prices

- In India, the **cost of electricity** from recently built coal power plants is still **cheaper than that from renewables** (although new renewable power is cheaper than both proposed new coal power).
- In addition, **investments in battery/storage technology** are required for renewable electricity to match the **continuous availability of coal-fired power**.
- Electricity tariffs for residential consumers are much lower than tariffs for industrial consumers, making residential consumers less likely to transition to renewable sources.

Irresponsible financing

- The number of countries using coal power has risen from 66 in 2000 to 78 in 2018.
- This is driven by larger economies providing public finance for fossil-based growth in the developing world.
- Moreover, G20 members provided **higher finance** for overseas coal projects than that for renewables.

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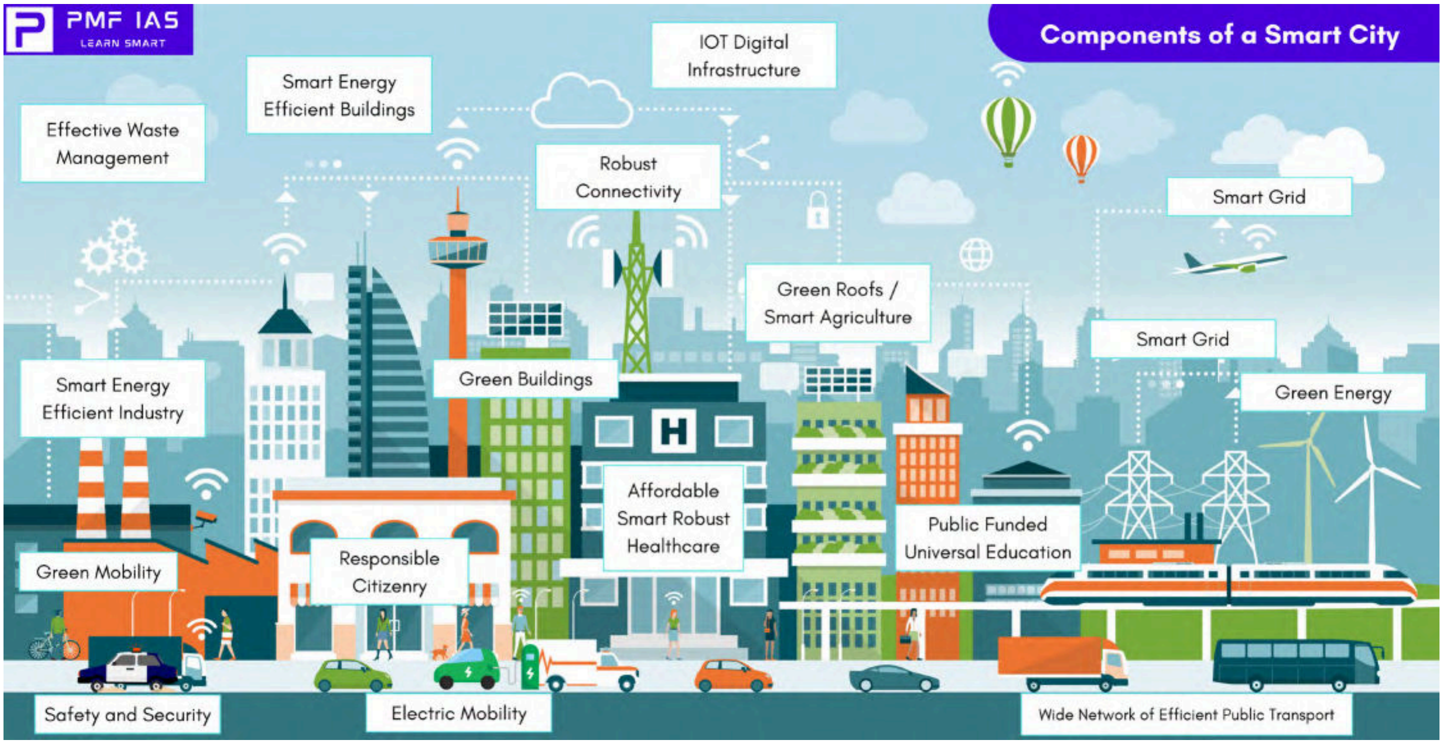
- **Africa**, in particular, is witnessing a rise in coal plants being planned 2018 onwards.
- These plants require more than eight times the region's existing coal capacity (**developed countries are shutting down their coal plants** and **finding newer markets for their coal in the developing world**).

28.6. Climate Smart Cities

- Climate-smart refers to an integrated approach to managing landscapes (urban centres), and ecosystems to address interlinked challenges of sustainable development and climate change.
- **Cities are responsible for 70% of global greenhouse gas emissions** (**UNDP report**) and face severest of consequences because of it (heat waves, urban heat island, water crisis, flooding, epidemics, conflicts, etc).
- Making cities more **resilient, sustainable, inclusive, and safe** is one of the **United Nations' Sustainable Development Goals (SDG 11)**.
- Modifying the heat-generating and heat-retaining nature of cities (public transport, electric vehicles, clean fuels, etc.) is a critical part of making them resilient, sustainable, inclusive, and safe (**Climate Smart**).
- Reducing the heat-retaining nature of cities will ultimately **reduce their carbon footprint** (lower emissions because of the **reduced electricity consumption — coal power** is the largest source of GHG emissions).



28.6.1. Measures Required to Reduce the Heat-Retaining Nature of Cities

- Use **light asphalt** instead of dark asphalt in road construction and roofing.
- **Cool pavements** and **rooftops** designed to reflect more sunlight and absorb less heat.
- **Green roofing:** roofs covered with green vegetation (both the above methods reduce air conditioning).
- Transition away from heat-absorbent materials, towards alternative construction materials & technologies.
- **Decentralization of development** and building green cities (e.g., **Dholera Smart City Gujarat**).
- Relocate polluting industries away from cities.
- Increasing tree and vegetation cover within cities.
- Consider heat wave as a natural disaster.
- Improve the overall ventilation of the cities.

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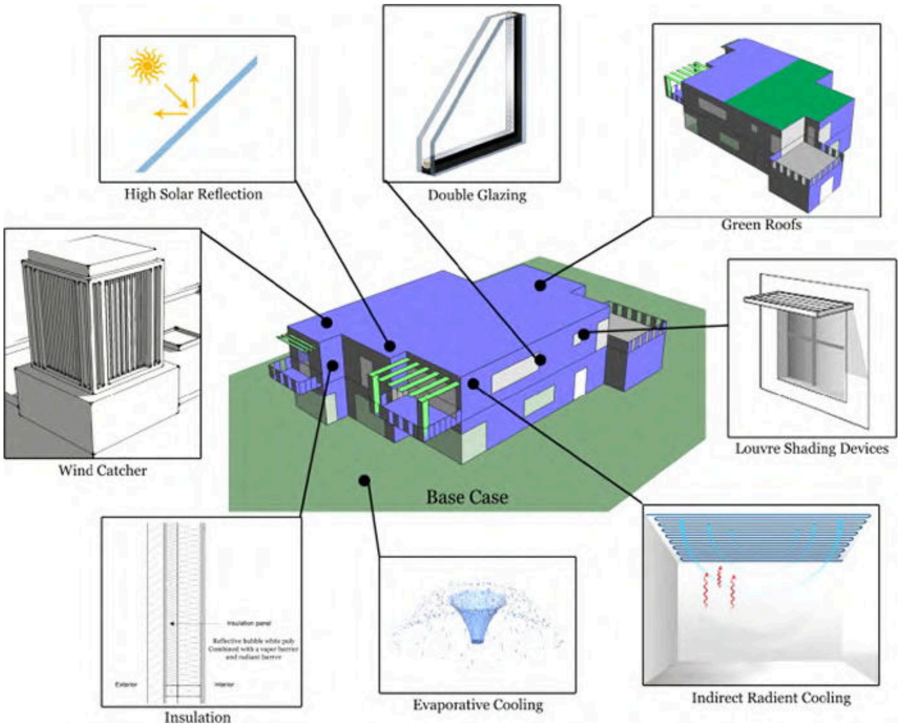
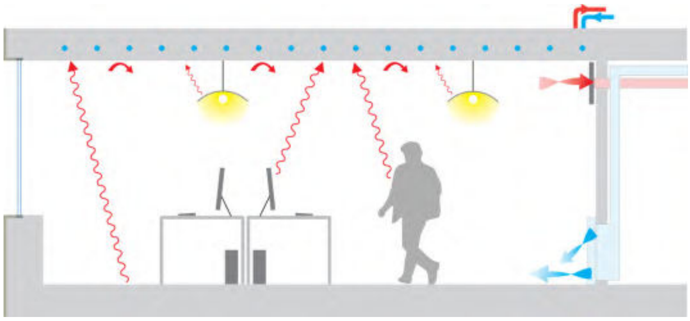
- ✓ Stuttgart in Germany, which is located in a weak wind-flow region, has progressively implemented policies to improve ventilation.
- ✓ In **Singapore**, the government is using urban environmental modelling to design and orient blocks of flats to maximise wind flow and shade in estates.

- Develop a strategy to incorporate the **green belt concept in urban planning** and implement **building codes** that entail **passive cooling practices** (use energy from the environment to dissipate heat).
  - ✓ **Double glazing:** reducing heat transfer by using two panes of glasses with space between them filled with heat trapping gases like argon.
  - ✓ **Evaporative cooling via fountain:** heat is lost in the form of latent heat of evaporation.
  - ✓ **Indirect radiant cooling:** heat is transferred from low conducting materials like humans, furniture to high conducting materials like metals.





28.6.2. Cooling Singapore – A Case Study

- Multi-institute initiative called **Cooling Singapore** aims at developing a roadmap towards **reducing the urban heat island (UHI)** effect in Singapore and thereby also improving **outdoor thermal comfort (OTC)**.

Components of 'Cooling Singapore'

- **Green Roofs/eco roofs:** placing a vegetative layer such as plants, shrubs, grass, and/or trees on rooftops.

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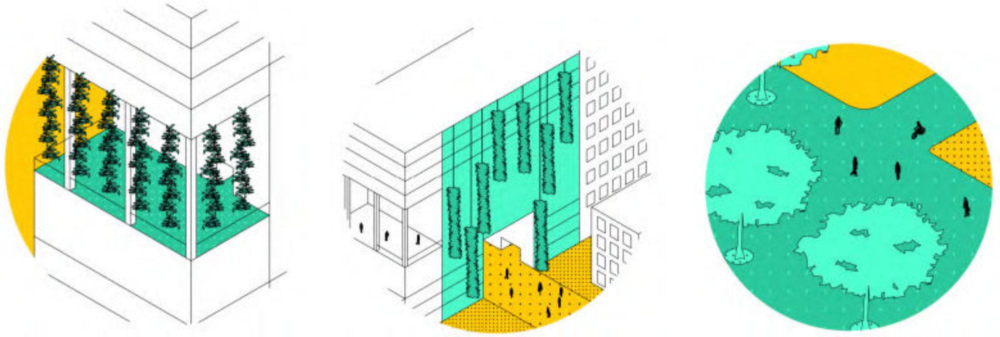
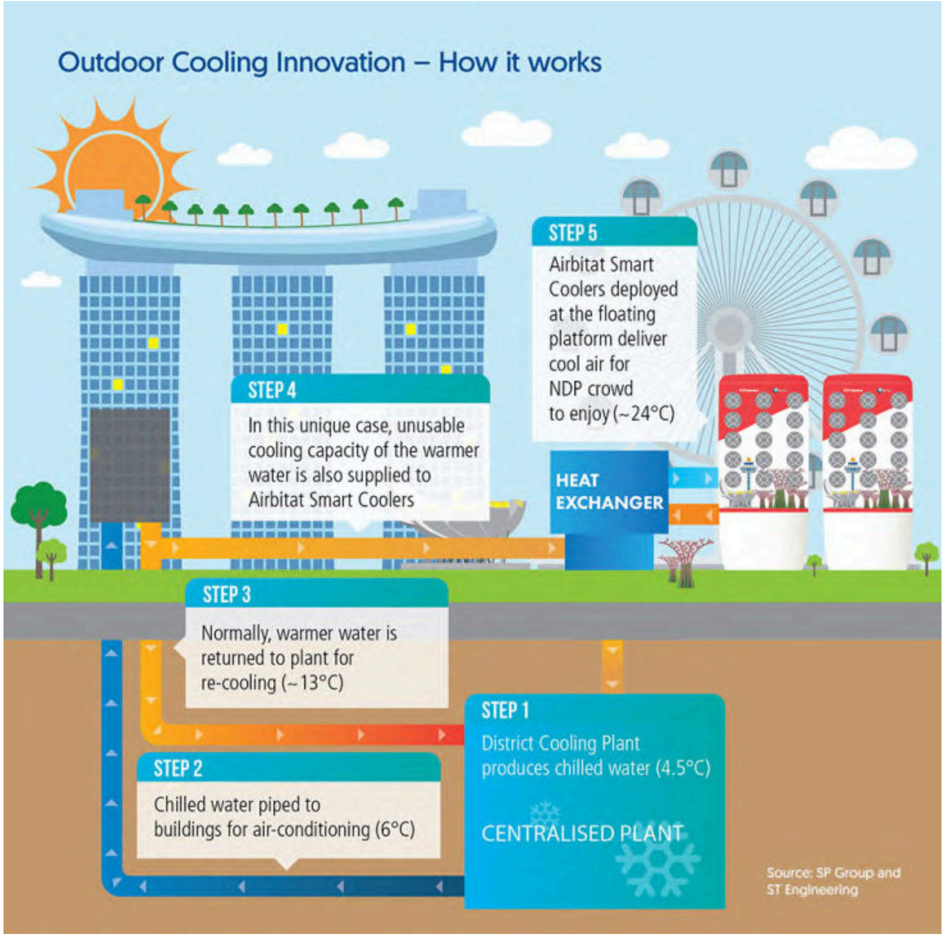
- **Vertical Greenery**: involves growing of vegetative elements on the external facade of the building envelope. They are also called **living walls** and **vertical gardens**.



- **Vegetation Around Buildings:** can provide shade to pedestrians, building and ground surfaces.
- **Green Pavements:** reduces the amount of artificial material on urban pavements with the replacement of natural soil elements with grass.
- **Macroscale Urban Greening:** large-scale increase of the presence of vegetation in urban areas focusing on big urban parks, forests and natural reservoirs.
- **Urban Farming:** practice of growing or producing food within urban areas.
- **Singapore District Cooling: centralizing the cooling plants saves 40% of electricity**.



28.6.3. Measures Taken in India

- **Cool roof** and **Cool pavement** programmes, which are already a component of Indian cities' **heat action plans**, involve **lightening roof and pavement colours** to reduce heat absorption.

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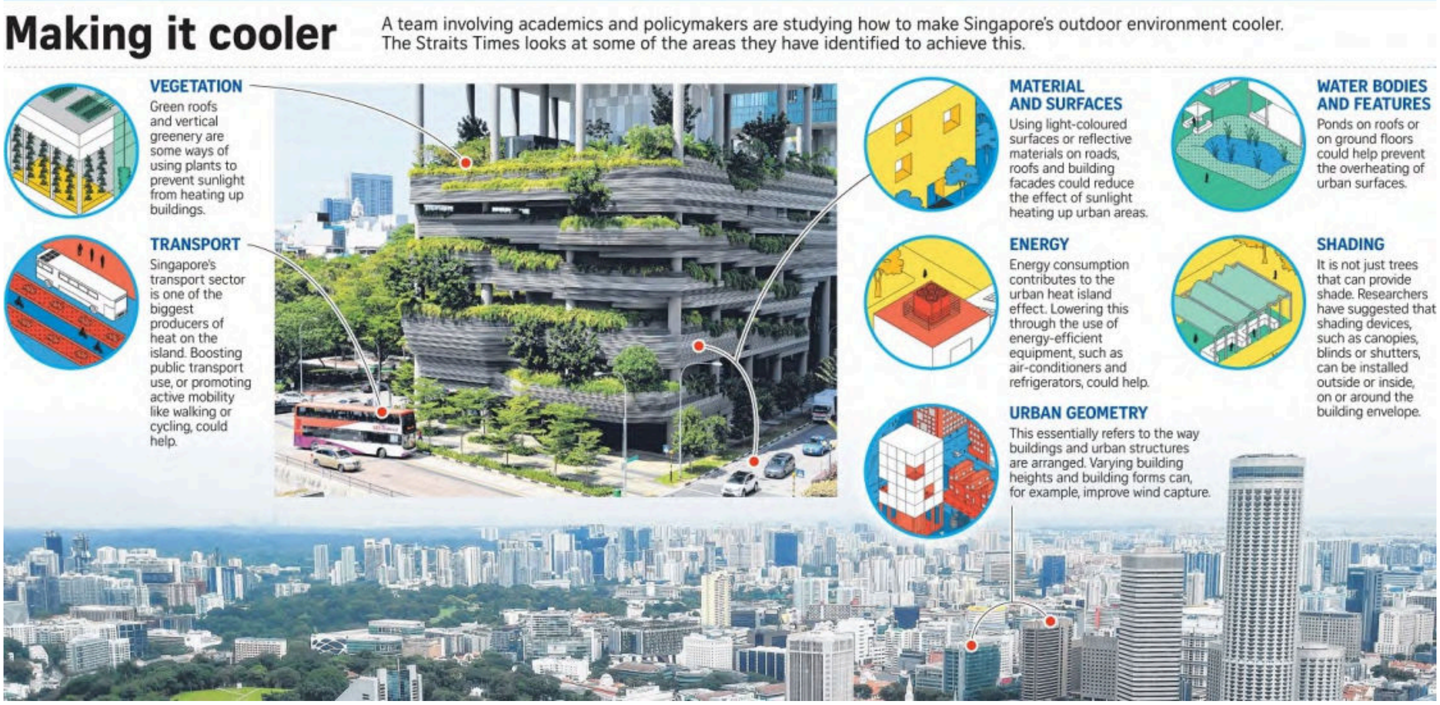
- The **National Mission on Sustainable Habitat** is aimed at transition away from heat-absorbent materials.
- The **Building Material and Technology Promotion Council (BMTPC)** under the Union Ministry of Housing and Urban Affairs (MHUA) promotes many alternative materials & technologies.



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- **Climate-Smart Cities Assessment Framework** for **climate-sensitive approach to urban planning.**

Climate-Smart Cities Assessment Framework (CSCAF)

- By 2030, 40% of India's population is expected to live in Cities.
- The **Ministry of Housing and Urban Affairs** has initiated several missions to manage this growth.
- **Climate-Smart Cities Assessment Framework (CSCAF)** is one such measure.
- The CSCAF initiative intends to inculcate a **climate-sensitive** approach to **urban planning** & development.
- It is a step to adopt, implement, and disseminate the best practices adopted by our cities and further set standards in comparison to the international efforts towards sustainable, & resilient urban habitats.
- The **Climate Centre for Cities** under **National Institute of Urban Affairs (NIUA)** is supporting **MoHUA** in implementation of CSCAF.
- Other programmes like **Green India Mission, National Clean Air Programme, Atal Mission for Rejuvenation and Urban Transformation (AMRUT** — providing basic amenities to improve urban life), **Swachh Bharat Mission, and Urban Transport** are supporting the cities in becoming **Climate Smart**.

Climate-Smart Cities Assessment Framework (CSCAF 2.0)

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- **Climate-Smart Cities Assessment Framework (CSCAF 2.0)** has been launched by the **Ministry of Housing and Urban Affairs (MoHUA)**.
- The **objective of CSCAF** is to provide a **clear roadmap** for cities **towards combating Climate Change** while planning and implementing their actions.
- The framework has **28 indicators across five categories** namely.
  1) **Energy and Green Buildings,**
  2) **Urban Planning, Green Cover & Biodiversity,**
  3) **Mobility and Air Quality,**
  4) **Water Management and**
  5) **Waste Management.**

Q. Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures. (UPSC CSE Mains 2020 – 250 words).

- You must include the impact of aerosols (due to air pollution) on regional rainfall distribution.
- You must discuss issues like wetland encroachments, climate change, poor drainage (clogging by plastic), etc.

Green Rating for Integrated Habitat Assessment (GRIHA)

- **GRIHA** is a **national rating tool** that assesses the performance of buildings against certain benchmarks.
- It evaluates the **environmental performance** of a building holistically, thereby providing a definitive standard for what constitutes a **green building**.
- It is developed by **The Energy & Resources Institute (TERI)** with support from **Ministry of New & Renewable Energy (MNRE)**.

Some of the benefits of a green building are

- Reduced energy consumption without sacrificing the comfort levels.
- Reduced destruction of natural areas, habitats, & biodiversity, & reduced soil loss from erosion etc.
- Reduced air & water pollution (with direct health benefits).
- Reduced water consumption.
- Limited waste generation due to recycling & reuse.

28.7. Transition to Green Economy

- Three priorities in transition of economy to green economy are
  a) Decarbonizing the economy;
  b) Commit the environmental community to justice and equity; and
  c) Conserve the biosphere.

28.7.1. Measures to Adapt Green Economy

- Energy audit can reduce your building's climate footprint.
- Sustainable fishing practices.
- Sustainably managed forests.
- Usage electronic files to reduce your demand for paper products.
- Support certified sustainable forest products.
- Car-pooling or taking public transport.
- Walking or riding a bike for short trips.
- Wise water use.

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- Development of clean, renewable energy by using solar, wind, tidal, etc will contribute to green economy.
- Recycling appropriate materials and composting food waste.
- Moving towards a green economy has the potential to achieve sustainable development.

28.7.2. Green Contracts

- **Green Contracts** refers to **commercial contracts** which mandate that **contracting parties cut down greenhouse gas emissions at different stages of delivery of goods/services**.
- The process of implementing a green contract **may commence at the bidding stage itself**, when various interested companies participate in the tender process.

Green tender

- **Green tender** may prescribe necessary **Green Qualifications**, which can be considered when awarding the contract to a bidder.
- Once such a bidder is chosen, the **contracting agreement** between the parties can prescribe the **green obligations** in detail, thus making the obligations **binding & enforceable** in the eyes of the law.

Advantages

- Decreased Environmental Impact like lower carbon emissions.
- Improved goodwill of the corporation in market.
- Corporations can avail tax rebates.

Concerns

- There is **no effective audit mechanism for implementing** these contracts in letter & spirit.
- **Green contracts are more expensive** than the **brown contracts** (**normal contracts without taking environment into account**).

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29. International Environmental Conventions, NGOs and Laws – Part I

Nature conservation

- United Nations Conference on Environment and Development (UNCED)
- Convention on Biological Diversity (CBD)
- Ramsar Convention on Wetlands (explained in "Wetland Ecosystem")
- Convention on International Trade in Endangered Species of Fauna and Flora (CITES) (explained in "Wildlife Conservation")
- The Wildlife Trade Monitoring Network (TRAFFIC) (explained in "Wildlife Conservation")
- Convention on the Conservation of Migratory Species (CMS) (explained in "Wildlife Conservation")
- Global Tiger Initiative and Global Tiger Forum (GTF) (explained in "Wildlife Conservation")
- Hazardous material (explained in in "Solid Waste")
- Stockholm Convention (mentioned under "Hazardous Waste")
- Basel Convention (mentioned under "Hazardous Waste")
- Rotterdam Convention (mentioned under "Hazardous Waste")

Land

- United Nations Convention to Combat Desertification (UNCCD) (explained in "Land Degradation")

Marine environment

- International Whaling Commission (IWC)

Atmosphere

- Vienna convention and Montreal Protocol (explained in "Ozone Depleting Substances")
- United Nations Framework Convention on Climate Change (UNFCCC)
- Kyoto Protocol

29.2. United Nations Conference on the Human Environment (1972)

- The **United Nations Conference on the Human Environment (Stockholm Conference)** was first held in **Stockholm, Sweden**, in 1972.
- It marked the **emergence of international environmental law**.
- The participants adopted **Stockholm Declaration** and **Action Plan for the Human Environment**.

29.2.1. Stockholm Declaration

- **Stockholm Declaration** is also known as **The Declaration on the Human Environment**.
- It **set out the principles** for various international environmental issues, natural resource management, pollution prevention and the relationship between the environment and development.
- **Some principles of the Stockholm Declaration:**
  - ✓ Human Rights must be asserted, apartheid and colonialism condemned
  - ✓ Natural resources must be safeguarded
  - ✓ **Poverty alleviation for protecting the environment**
  - ✓ Weapons of Mass destruction must be destroyed
  - ✓ Non – renewable sources must not exhaust
- The Stockholm Conference motivated countries **to create environmental ministries and agencies**.
  - ✓ **Department of Environment in India** was created in **1980**

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- ✓ **Ministry of Environment and Forests (MoEF)** in **1985**
- ✓ In 2014, the ministry was renamed to the current title of **Ministry of Environment, Forest, and Climate Change (MoEFCC)**
- **Stockholm Conference** paved the way for the creation of **UN Environment Programme (UNEP)**.

29.3. United Nations Environment Programme (UNEP) or UN Environment

- UNEP is an agency of the **United Nations**.
- It **coordinates the UN's environmental activities**.
- It **assists developing countries** in implementing environmentally sound policies and practices.
- It has **overall responsibility for environmental problems** among United Nations agencies.
- Addressing **climate change** or **combating desertification**, are overseen by other specialized **UN agencies** like the **UNFCCC** and the **UNCCD**.
- UNEP's activities cover a wide range of issues regarding the atmosphere, marine and terrestrial ecosystems, environmental governance, and **green economy**.

29.3.1. Agencies Established/Monitored/Supported/Implemented by UNEP

- The **World Meteorological Organization** and **UN Environment** established the **Intergovernmental Panel on Climate Change (IPCC** — explained in the chapter on Climate Change**)** in 1988.
- UN Environment is also one of the several **Implementing Agencies** for the **Global Environment Facility (GEF)** and the **Multilateral Fund for the Implementation of the Montreal Protocol**.
- It is also a member of the **United Nations Sustainable Development Group (UNSDG)**.
- It aims to help the world meet the **17 Sustainable Development Goals**.
- It has registered several successes, such as the **1987 Montreal Protocol**, and the **2012 Minamata Convention**, a **treaty to limit toxic mercury**.
- UNEP **hosts the secretariats** of several multilateral environmental agreements/research bodies including:
  - ✓ **Convention on Biological Diversity (CBD)**
  - ✓ **Minamata Convention on Mercury (MCM)**
  - ✓ **Convention on Migratory Species (CMS)**
  - ✓ **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**
- The **solar loan programme** sponsored by **UN Environment** helped finance **solar power systems in India**.

29.3.2. Global Environment Facility (GEF)

- The GEF was established on the eve of the **1992 Rio Earth Summit**.
- It is an **independently operating financial organization**.

Areas of work

- The GEF provides grants for projects related to **biodiversity, REDD+ (Sustainable Forest Management), climate change, land degradation, the ozone layer, persistent organic pollutants**, etc.
- It unites countries with institutions, civil society, NGOs, and the private sector to help tackle our planet's **most pressing environmental problems** while supporting national **sustainable development** initiatives.
- GEF runs a **Small Grants Programme** that provides financial support to projects which embody a **community-based approach**.

The GEF Also Serves as Financial Mechanism for The Following Conventions:

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- **Convention on Biological Diversity (CBD)**
- **United Nations Framework Convention on Climate Change (UNFCCC)**
- **UN Convention to Combat Desertification (UNCCD)**
- **Stockholm Convention on Persistent Organic Pollutants (POPs)**
- **Minamata Convention on Mercury**
- The GEF, although **not linked formally** to the **Montreal Protocol**, **supports implementation** of the Protocol in **countries with economies in transition**.

The GEF works with18 agencies. Notable ones among them are:

1) **United Nations Development Programme (UNDP)**
2) **United Nations Environment Programme (UNEP)**
3) **World Bank (WB)**
4) **Food and Agriculture Organization (FAO)**
5) **Asian Development Bank (ADB)**
6) **International Fund for Agricultural Development (IFAD)**
7) **World Wide Fund for Nature (World Wildlife Fund) (WWF)**
8) **Conservation International (CI)**
9) **International Union for Conservation of Nature (IUCN)**

Q. With reference to 'Global Environment Facility', which of the following statements is/are correct?

a) It serves as financial mechanism for 'Convention on Biological Diversity' and 'United Nations Framework Convention on Climate Change'.
b) It undertakes scientific research on environmental issues at global level
c) It is an agency under OECD to facilitate the transfer of technology and funds to underdeveloped countries with specific aim to protect their environment.
d) Both (a) and (b)

Explanation:

- GEF is an **independent financial organization (not a research body)**.
- It may fund **scientific research**, but it is **not directly involved in scientific research**.
- **IPCC takes care of most of the research work**.

Answer: a)

Agencies Funded by GEF

Special Climate Change Fund (SCCF) – 2001

- It aims to address the specific needs of developing countries under the **UNFCCC** to **adapt to the impact of climate change & increase resilience.**
- It covers the **incremental costs of interventions** to address climate change adaptation relative to a development baseline.
- It is **administered** by the **Global Environment Facility (GEF).**
- SCCF is **open to all** vulnerable developing countries (**Non-Annex 1** countries under Kyoto Protocol).

Least Developed Countries Fund – 2001

- Least Developed Countries Fund (LDCF) was established to support the LDC work programme under the UNFCCC.
- LDCF funding helps recipient countries address their **short, medium & long-term resilience needs &** reduce climate change vulnerability in priority sectors and ecosystems.

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- It is operated by the **Global Environment Facility (GEF)**.

Global Wildlife Programme

- It was launched in **2015.**
- It is a **World Bank-led** & GEF-funded global partnership.
- **Aim:** To **combat trafficking** in Wildlife

Q. Consider the below statements about Global Wildlife Programme (GWP):

1) GWP is a CITES led global partnership that promotes wildlife conservation and sustainable development by combating illicit trafficking in wildlife.
2) The GWP is funded by the Global Environment Facility (GEF).

Which of the statements given above are correct?

a) 1 only
b) 2 only
c) Both
d) None

Correct Answer: B

29.3.3. Multilateral Fund (MLF) for the Implementation of the Montreal Protocol

- The MLF provides funds **to help developing countries** comply with their obligations under the **Montreal Protocol** to **phase out the use of ozone-depleting substances (ODS)** at an agreed schedule.
- It was established by the **London Amendment** to the **Montreal Protocol** in 1990.
- Countries eligible for this assistance are those with an annual per capita consumption of ODS of less than 0.3 kg/year, as defined in Article 5 of the Protocol.
- They are referred to as **Article 5 countries** (**includes India** and developing and underdeveloped countries).

29.3.4. Faith for Earth Initiative

- It was launched in **2017 by UNEP.** It aims to strategically engage with faith-based organisations and partner with them to collectively **achieve the SDGs**.
- It aims to create a global **"Coalition for Creation"** to facilitate policy dialogue on environmental issues that would encourage innovative approaches to finding long-lasting solutions to environmental challenges.

29.4. UNCED or Earth Summit 1992, Rio De Janeiro Brazil

- **The United Nations Conference on Environment and Development (UNCED)** is popularly known as **Earth Summit 1992**.
- It succeeded in **raising public awareness** of the **need to integrate environment & (sustainable) development**.
- 190 countries pledged their commitment to achieve by 2010, a significant reduction in the current rate of biodiversity loss at global, regional, and local levels.

29.4.1. Post UNCED

- As a follow-up to UNCED, the **World Summit on Sustainable Development (Rio+10)** was held in **2002 in Johannesburg, South Africa**.
- In **2012**, the **United Nations Conference on Sustainable Development** was also held in Rio and is also commonly called **Rio+20 or Rio Earth Summit 2012**.

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- The issues touched included:
  - ✓ **checking production of toxic components**, such as **lead in gasoline**, or poisonous waste including radioactive chemicals,
  - ✓ **alternative sources of energy** to replace the use of fossil fuels,
  - ✓ new reliance on **public transportation** systems to reduce vehicle emissions, congestion in cities,
  - ✓ the health problems caused by **pollution**, and
  - ✓ the growing usage and limited supply of **water**.

Q. What is Rio+20 Conference, often mentioned in the news?

a) It is the United Nations Conference on Sustainable Development
b) It is a Ministerial Meeting of the World Trade Organization
c) It is a Conference of the Inter-governmental Panel on Climate Change
d) It is a Conference of the Member Countries of the Convention on Biological Diversity

Explanation:

1. **Earth Summit 1992 (Rio de Janeiro) → UN Conference on Environment & Development**
2. **Earth Summit 2002 (Rio+10) (Johannesburg) → World Summit on Sustainable Development**
3. **Earth Summit 2012 (Rio+20) (Rio de Janeiro) → UN Conference on Sustainable Development**

Answer: a)

29.4.2. Significance of Earth Summit 1992

- The Earth Summit resulted in the following documents:
  1. **Rio Declaration:** Principles intended to guide countries in **future sustainable development**.
  2. **Agenda 21:** Non-binding action plan of the United Nations regarding sustainable development.
  3. **Forest Principles:** **Non-legally binding** document on Conservation and Sustainable Development of All Types of Forests.

Landmark Agreements

- An important achievement of the Earth Summit was an agreement on the **Climate Change Convention (UNFCCC)** which in turn led to the **Kyoto Protocol** & **Paris Agreement**.
- Important **legally binding agreements** opened for signature under the aegis of the **Earth Summit** are:
  a) **Convention on Biological Diversity (CBD).**
  b) **United Nations Convention to Combat Desertification (UNCCD).**
  c) **United Nation Framework Convention on Climate Change (UNFCCC)**

29.4.3. High-level Political Forum on Sustainable Development (HLPF)

- It is a forum under the **UN Economic and Social Council (ECOSOC)** tasked with **overseeing the outcomes of the 1992 Earth Summit**.
- **HLPF** meets both under the General Assembly **every 4 years** and the ECOSOC in other years.
- It is responsible for the follow up and the **review of progress of implementation** of the following:
  - ✓ **Agenda 21**
  - ✓ **Johannesburg Declaration (Rio+10)**
  - ✓ **Barbados Programme of Action (Sustainable Development of SIDS)**
  - ✓ **Rio+20**
  - ✓ **LDC-IV (4th United Nations Conference on the Least Developed Countries)**

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✓ As well as the relevant outcomes of other United Nations summits and conferences.

29.4.4. UN Agenda 21

- Agenda 21 is a **non-binding action plan** of the **UN** related to **sustainable development**.
- The number 21 refers to an agenda for the 21st century.
- Its aim is achieving **global sustainable development**.
- Since 2015, **Sustainable Development Goals** are included in the **Agenda 2030**.

Q. With reference to 'Agenda 21', sometimes seen in the news, consider the following statements: (2016)

1) It is a global action plan for sustainable development
2) It originated in the World Summit on Sustainable Development held in Johannesburg in 2002.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Explanation:

- **Agenda 21 came out as a part of Earth Summit 1992**

Answer: a) 1 only

29.4.5. UN Agenda 2030 – Sustainable Development Goals (SDGs)

- The UN 2030 Agenda's Sustainable Development Goals (SDG) aim at **eradicating poverty in all forms** and "**seek to realize the human rights of all and achieve gender equality**".
- The Sustainable Development Goals (SDGs) are a collection of **17 global goals, and their 169 targets**, set by the **United Nations General Assembly** in **2015** for the year **2030** (UNGA resolution "2030 Agenda").

Goal 2: Zero hunger

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"End hunger, achieve food security and improved nutrition, and promote sustainable agriculture".

- This would be accomplished by **doubling agricultural productivity and incomes** of small-scale food producers (women and indigenous peoples),
  - ✓ By ensuring **sustainable food production systems**, and
  - ✓ By progressively improving **land and soil quality**.
- Other targets deal with maintaining genetic diversity of seeds, increasing access to land, preventing trade restriction and distortions in world agricultural markets, eliminating wastage and ending malnutrition.

Goal 6: Clean water and sanitation

"Ensure availability and sustainable management of water and sanitation for all."

- Safe drinking water and hygienic toilets.
- Toilets in schools and work places.
- **Equitable sanitation** for addressing the specific needs of women and girls, disabled, aged persons.

Goal 7: Affordable and clean energy

"Ensure access to affordable, reliable, sustainable and modern energy for all."

- 2030 target: access to affordable and reliable energy while increasing the share of renewable energy.

Goal 8: Jobs and Growth

- "**Promote sustained, inclusive and sustainable economic growth, full and productive employment**."

Partnership for Action on Green Economy (PAGE)

- PAGE, launched in 2013, is a direct response to the **Rio+20 Declaration**, **The Future We Want**.
- PAGE seeks to assist countries in achieving **SDG (2030 Agenda),** especially SDG 8: "**Promote sustained, inclusive and sustainable economic growth, full and productive employment**."
- **India** joined PAGE in **2013.**
- PAGE brings together the expertise of **five UN agencies – UNEP, ILO, UNIDO, UNDP** and **UNITAR**.
  - ✓ ILO: International Labour Organization
  - ✓ UNIDO: UN Industrial Development Organization
  - ✓ UNITAR: UN Institute for Training and Research.

Q. The Partnership for Action on Green Economy (PAGE), a UN mechanism to assist countries transition towards greener and more inclusive economies, emerged at (2018)

a) The Earth Summit on Sustainable Development 2002, Johannesburg
b) The United Nations Conference on Sustainable Development 2012, Rio de Janeiro
c) The United Nations Framework Convention on Climate Change 2015, Paris
d) The World Sustainable Development Summit 2016, New Delhi

Answer: b)

Goal 11: Sustainable cities and communities

"Make cities and human settlements inclusive, safe, resilient, and sustainable."

- 2030 target is to ensure access to safe and affordable housing.

Goal 12: Responsible consumption and production

"Ensure sustainable consumption and production patterns."

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- The targets of Goal 12 include:
  - ✓ using eco-friendly production methods
  - ✓ reducing the amount of waste.
  - ✓ Increase national recycling rates.

Goal 13: Climate action

"Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy."

Goal 14: Life below water

"Conserve and sustainably use the oceans, seas and marine resources for sustainable development."

- The targets include
  - ✓ preventing and reducing marine pollution and acidification,
  - ✓ protecting marine and coastal ecosystems and regulating fishing.

Goal 15: Life on Land

"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss."

- Goal 15 calls for more attention to **preventing invasion of introduced species** and **more protection of endangered species**.

29.4.6. The History of Sustainable Development Goals

Brundtland Commission

- In 1983, the United Nations created the **World Commission on Environment and Development** (later known as the **Brundtland Commission**).
- It defined sustainable development as "**meeting the needs of the present without compromising the ability of future generations to meet their own needs**".

Q. Define the concept of carrying capacity of an ecosystem as relevant to an environment. Explain how understanding this concept is vital while planning for sustainable development of a region. (2019)

- Carrying capacity of an ecosystem refers to the maximum levels of the ecological/ecosystem services that an ecosystem can offer sustainably.
- Beyond the carrying capacity, the ecosystem is severely constrained/degraded. Examples:
  - ✓ Indian metropolitan cities have far exceeded their carrying capacity.
  - ✓ Agroecosystems in Punjab and Haryana are severely stressed due to rampant groundwater depletion and increased alkalinity.
  - ✓ Deforestation and plantation agriculture have exceeded the natural tolerance limits of the Western Ghats.
  - ✓ Poverty in the Indo-Gangegtic plains can be attributed to excessive population stress; and
  - ✓ Hydroelectric power projects and tourism in the Himalayas that have exacerbated the disaster potential.
- Understanding the concept of carrying capacity of an ecosystem is important for urban planning, sustainable resource extraction, population control, wildlife management, etc.

Rio+5 (1997)

- In 1997, the UN General Assembly held a special session Rio+5 to appraise the status of **Agenda 21**.
- **Agenda 21** is a **non-binding action plan** of the **UN** related to **sustainable development**.

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Rio+10 (2002) or Earth Summit 2002

- Rio+10 affirmed UN commitment to Agenda 21, alongside the **Millennium Development Goals**.
- **Johannesburg Declaration**: committing the nations of the world to sustainable development.

Rio+20 (2012) or Earth Summit 2012

- Rio+20 was a 20-year follow-up to the Earth Summit 1992 and 10-year follow-up to the Earth Summit 2002.
- It is also known as Rio 2012 or Earth Summit 2012.
- The **Sustainable Development Goals (SDGs)** were born at **Rio+20**.

Q. Consider the following statements: (2016)

1) The Sustainable Development Goals were first proposed in 1972 by a global think tank called the 'Club of Rome'.
2) The Sustainable Development Goals have to be achieved by 2030.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: b) 2 only

Millennium Development Goals (MDGs)

- The **Sustainable Development Goals (SDGs)** replaced the **MDGs in 2016**.
- The **Millennium Development Goals (MDGs)** were **eight development goals** for the year **2015**.
- MGDs had been established following the **Millennium Summit of the United Nations in 2000**.
- United Nations Millennium Declaration was adopted.

Millennium Development Goals by 2015

1. To eradicate extreme poverty and hunger
2. To achieve universal primary education
3. To promote gender equality and empower women
4. To reduce child mortality
5. To improve maternal health
6. To combat HIV/AIDS, malaria, and other diseases
7. To ensure environmental sustainability

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8. To develop a global partnership for development

29.5. United Nations Framework Convention on Climate Change (UNFCCC)

- UNFCCC is an international environmental treaty that came into existence under the aegis of **UN**.
- UNFCCC is negotiated at the **Earth Summit 1992** and was signed in **1992 in New York City**.
- As of July 2021, the UNFCCC has **197 parties**.
- **Role:** provide a framework for negotiating **specific international treaties (called "protocols")** that **aim to set binding limits on greenhouse gases**.
- **Objective: Stabilize greenhouse gas concentrations** in the atmosphere at a level that would prevent dangerous consequences.
- **Legal Effect:** Treaty is considered **legally non-binding**.
- The treaty itself **sets no binding limits on greenhouse gas emissions for individual countries**.

29.5.1. Conferences of the Parties (COP) to UNFCCC

- The COP is the **decision-making body** of UNFCCC.
- All States that are Parties to the Convention are represented at the COP.
- They review the implementation of any legal instruments that the COP adopts.
- They promote the effective implementation of the Convention.
- The first COP meeting was held in **Berlin, Germany in March 1995**.
- The parties to the convention met **annually** since 1995 till 2019. The 2020 COP was rescheduled to 2021.

List of UNFCCC Summits

- **1995: COP 1, The Berlin Mandate**
- 1996: COP 2, Geneva, Switzerland
- **1997: COP 3**, the **Kyoto Protocol** was concluded and established **legally binding obligations for developed countries to reduce their greenhouse gas emissions**.
- 1998: COP 4. Buenos Aires, Argentina
- 1999: COP 5, Bonn, Germany
- 2000: COP 6. The Hague. Netherlands
- 2001: COP 6, Bonn. Germany
- 2001: COP 7. Marrakech, Morocco
- **2002: COP 8, New Delhi, India**
- 2003: COP 9, Milan, Italy
- 2004: COP 10. Buenos Aires. Argentina
- **2005: COP 11/CMP 1, Montreal, Canada Montreal, (Kyoto Protocol was ratified in 2005)**
- 2006: COP 12/CMP 2, Nairobi. Kenya
- 2007: COP 13/CMP 3, Bali, Indonesia
- 2008: COP 14/CMP 4, Poznan. Poland
- 2009: COP 15/CMP 5, Copenhagen, Denmark
- 2010: COP 16/CMP 6, Canciin, Mexico
- 2011: COP 17/CMP 7, Durban, South Africa
- 2012: COP 18/CMP 8, Doha, Qatar
- 2013: COP 19/CMP 9, Warsaw, Poland
- 2014: COP 20/CMP 10. Lima, Peru

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- **2015: COP 21/CMP 11, Paris, France –** concluded the **Paris Agreement**
- 2016: COP 22/CMP 12, Marrakech, Morocco
- 2017: COP 23/CMP 13, Bonn, Germany.
- 2018: COP 24/CMP 14, Katowice, Poland.
- 2019: COP 25/CMP 15, Madrid (Spain)
- **2021: COP 26 (Oct-Nov 2021)/CMP 16**, **Glasgow (will be hosted by the UK in partnership with Italy)**.

29.5.2. Criticisms of the UNFCCC (Failures of UNFCCC)

- Nothing **except Kyoto Protocol** made any binding limits on GHG emissions.
- **Never achieved its stated goals** of reducing the emission of carbon dioxide.
- Negotiations are governed by consensus and small group of countries often block the negotiations.
- It is easy for the developed countries to escape from their responsibility: **United States**, one of the biggest polluters **never ratified Kyoto Protocol**.
- **Canada pulled out of Kyoto Protocol** citing wealth transfers of out the country due to binding limits.
- Treaty **does not cover developing countries that now include the largest CO_2 emitters (India & China)**.
- **Japan** and **Russia did not sign second Kyoto** term because it would impose restrictions on it not faced by their main economic competitors, China, India, and Indonesia.

29.6. Kyoto Protocol (COP 3; UNFCCC Summit 1997)

- The Kyoto Protocol was adopted in Kyoto, Japan, in 1997.
- **India ratified Kyoto Protocol in 2002**.
- The Kyoto Protocol came into force in February **2005**.
- There are currently 192 Parties.
- **USA never ratified Kyoto Protocol**.
- **Canada withdrew in 2012**.
- Goal: **Fight global warming by reducing greenhouse gas concentrations** in the atmosphere to "**a level that would prevent dangerous anthropogenic interference with the climate system**."
- Kyoto protocol aimed to cut emissions of greenhouse gases across the developed world by about **5 per cent by 2012 compared with 1990 levels**.
- The Protocol is based on the principle of **common but differentiated responsibilities**.
- **Kyoto Protocol** is the **only global treaty with binding limits on GHG emissions**.

The Kyoto Protocol Emission Target Gases

1. **Carbon dioxide (CO_2),**
2. **Methane (CH_4),**
3. **Nitrous oxide (N_2O),**
4. **Sulphur hexafluoride (SF_6),**
5. **Groups of hydro fluorocarbons (HCFs) and**
6. **Groups of Per fluorocarbons (PFCs)**

29.6.2. What is Common but Differentiated Responsibilities (CBDR) – Kyoto Protocol?

- It puts the obligation to reduce current emissions on **developed countries** on the basis that they are historically responsible for the current levels of greenhouse gases in the atmosphere.
- CBDR divides countries into two categories:

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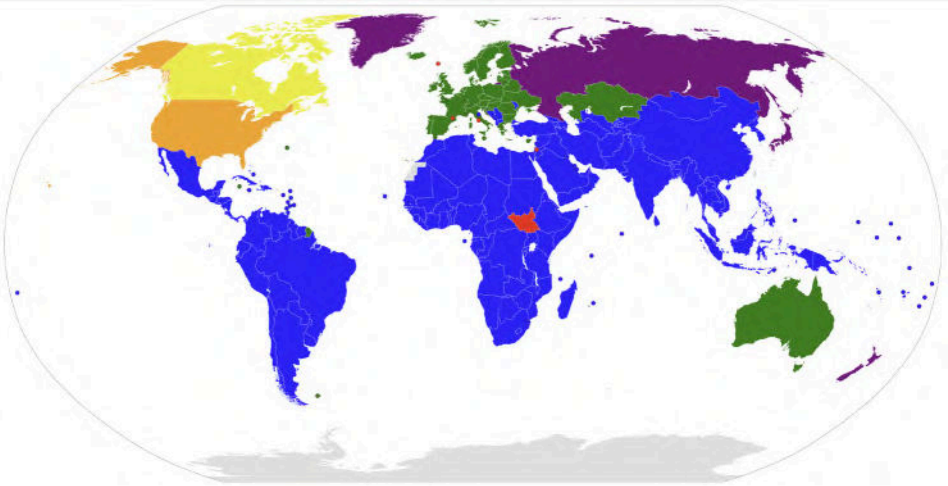
1. **Historically biggest polluting developed countries** like US, UK, France, Japan, Russia etc. (they are polluting the earth since Industrial Revolution).
2. **Recently polluting developing countries** like **China, India, Brazil**, etc. (polluting since 1950s).

- **"Common"** ➔ Every country (developing & developed) must take part in the fight against climate change.
- **"But Differentiated Responsibilities"** ➔ Historically biggest polluters should do more compared to the recent polluters, i.e., **responsibilities proportional to pollution caused**.
- Thus, under CBDR, **developed countries** like US, UK, Russia etc. must contribute more to reduce GHGs by **accepting to certain binding limits on GHG emissions**.
- They must **contribute funds** towards reducing GHG emissions to developing & least developed countries.
- On the other hand, **developing and least developed countries** should do everything in their capacity to cut down their GHG emissions. But **nothing is binding on them, and every initiative is voluntary**.

29.6.3. Classification of Parties and their commitments – Kyoto Protocol

Annex I	• **Developed countries [US, UK, Russia etc.] + Economies in transition (EIT) [Ukraine, Turkey, some eastern European countries]**
Annex II	• **Developed countries** (Annex II is a subset of Annex I). • Required to provide **financial and technical support** to the **EITs** and **developing countries** to assist them in reducing their greenhouse gas emissions.
Annex B	• **Annex I Parties with first or second-round Kyoto greenhouse gas emissions targets**. • The first-round targets apply over the years **2008–2012** and the second-round Kyoto targets, which apply from **2013–2020**. • **Compulsory binding targets** to reduce GHG emissions.
Non-Annex I	• Parties to the UNFCCC **not listed in Annex I** of the Convention (mostly low-income developing countries). • **No binding targets** to reduce emissions.
LDCs	• Least-developed. **No binding targets**.

- **Developing countries may volunteer to become Annex I countries** when they are sufficiently developed.



Annex B parties with binding targets in the second period
Annex B parties with binding targets in the first period but not the second
Non-Annex B parties without binding targets
Annex B parties with binding targets in the first period but which withdrew from the Protocol
Signatories to the Protocol that have not ratified
Other UN member states and observers that are not party to the Protocol

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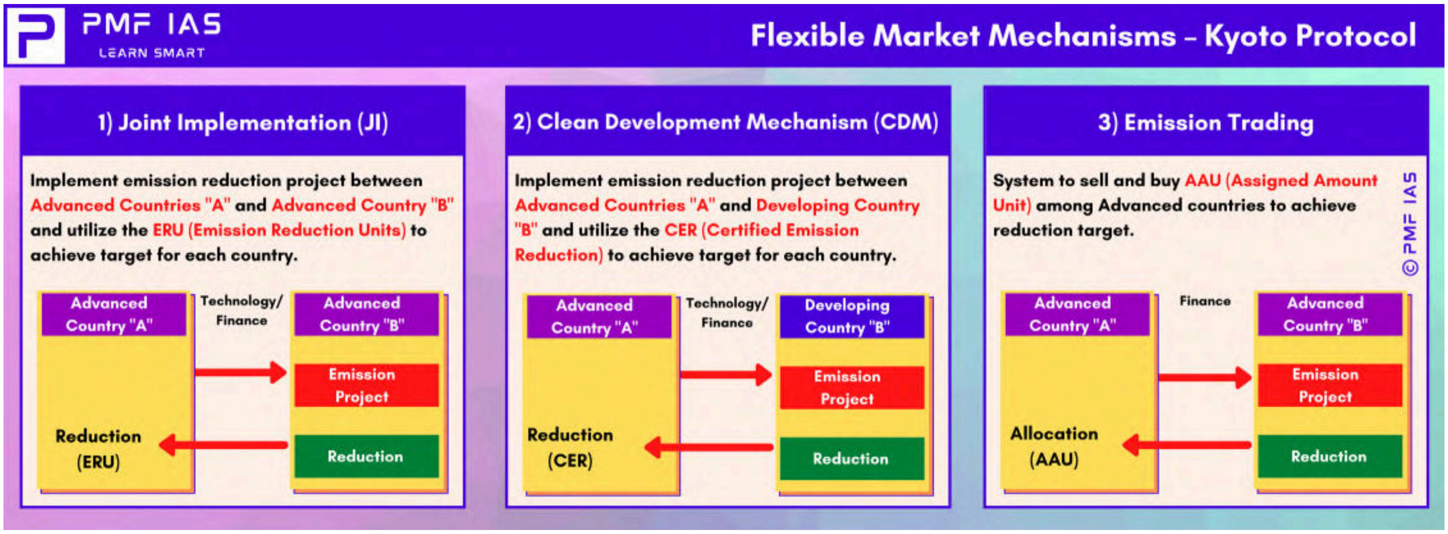
29.6.4. What is Commitment Period? Doha Amendment to Kyoto Protocol

- Under the Kyoto Protocol, there are two commitment periods: **1) 2008 – 2012** **2) 2013 – 2020**
- The **second** commitment period was agreed on in 2012, known as the **Doha Amendment to the protocol**.
- Each commitment period has its own binding targets set for **developed countries**.
- During first commitment period (2008-12), more than 35 countries had binding targets. Nations that missed their Kyoto target in 2012 **incurred a penalty of an additional third** added to whatever cut they agree under a new treaty.
- **Canada withdrew in 2012 after the first commitment period**.
- **Japan, New Zealand** and **Russia** have participated in Kyoto's first-round but have not taken on new targets in the second commitment period.
- **The Doha Amendment** needed acceptance by at least 144 states to enter into force.
- **As of October 2020, 147 states had accepted the Doha Amendment**.
- It entered into force on **31 December 2020** and **ended on the same day!** Thus, the **second commitment period is an abject failure**.
- Negotiations were held in Lima in 2014 to agree on a post-Kyoto legal framework.
- **China, India,** and the **United States (three big villains)** have all signalled that they will not ratify any treaty that will commit them legally to reduce CO_2 emissions.

Criticism of Kyoto Protocol

- Under Kyoto Protocol, Annex 1 countries can meet their targets by cutting emissions or buying unused allowances (carbon credits, carbon trading) from other countries. This kind of approach ignores long term social and economic costs. It is like committing only half of what one needs to commit.
- Kyoto Protocol is based on the "common but differentiated responsibility" approach to global warming. Under CBDR, many countries were allowed to increase pollution. It excluded most polluting countries like China and India, which have since become the world's largest and fourth largest polluters.

29.7. Flexible Market Mechanisms Under Kyoto Protocol



- Countries bound to Kyoto targets have to meet them largely through domestic action — that is, to reduce their emissions onshore.
- **But they can meet part of their targets through three "market-based mechanisms"**.

The Kyoto Flexible Market Protocol mechanisms include:

1. **Clean Development Mechanism (CDM)**

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2. **Emission Trading**
3. **Joint Implementation (JI)**

Expected Benefits of Flexible Market Mechanisms

- Stimulating **green investment in developing countries**.
- Including the **private sector** in this endeavour to cut and hold steady GHG emissions at a safe level.
- It also makes "**leap-frogging**" — possibility to skip older, dirtier technology for newer, cleaner infrastructure and systems, with obvious longer-term benefits.

29.7.2. Clean Development Mechanism (CDM)

- CDM allows a country with an emission-reduction commitment under the Kyoto Protocol (**Annex B Party like Australia**) to **implement an emission-reduction project** in **developing countries (like India)**.
- Such projects can earn **certified emission reduction (CER) credits**, each equivalent to **one tonne of CO_2**, which **can be counted towards meeting Kyoto targets**.
- In simple terms: Developed countries emit more and **lose carbon credits**. They provide financial assistance to **developing and least developed countries (Non-Annex)** to create clean energy and **gain some carbon credits** thereby meeting their Kyoto Quota (Kyoto units) of emissions without violations.
- Suppose a developed country has a Kyoto Quota of 100 Carbon Credits, it can emit 100 tonnes of CO_2.
- Due to negligence, it emits 110 tonnes of CO_2, i.e., 10 carbon credits are lost (Kyoto Quota violation).
- Now the country has to make up for its lost carbon credits to avoid penalty.
- So, it invests some money (equal to 10 carbon credits) in developing and LDCs to build clean energy infrastructure like solar plants, wind farms etc. and will make up for its 10 lost carbon credits and avoid penalty.

29.7.3. Carbon Credits Trading (Carbon Trading/Emission Trading)

Carbon credit

- A carbon credit (often called a **carbon offset**) is a **tradable certificate or permit**.
- One carbon credit is equal to **one tonne of carbon dioxide**.
- Carbon credits or carbon offsets can be acquired through **afforestation, renewable energy, CO_2 sequestration, methane capture, buying from an exchange (carbon credits trading)** etc.

Carbon trading

- Carbon trading is the name given to the **exchange of emission permits (carbon credits)**.
- This exchange may take place within the economy or may take the form of international transaction.
- Under Carbon Credits Trading mechanism **countries/companies that emit more carbon than the quota allotted to them buy carbon credits from those that emit less**.
- In Carbon trading, one credit gives the country or a company right to emit **one tonne of CO_2**.
- A developing nation such as **India, turns out to be a seller of such credits**.
- Carbon credits are traded at various exchanges across the world.
- **Multi-Commodity Exchange of India** (MCX) launched futures trading in carbon credits in 2009.

Types of Carbon Trading

1. **Emission trading**
2. **Offset trading**

Emission trading/'cap-and-trade'

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- Emissions trading allows countries to sell unused emission units to countries that have exceeded their targets.
- Carbon is tracked and traded like any other commodity in a "carbon market."

Offset Trading/ Carbon Project / 'baseline-and credit' trading

- Another variant of carbon credit is to be earned by a country by investing some amount of money in such projects, known as **carbon projects**, which will emit lesser amount of greenhouse gass into the atmosphere.

29.7.4. Joint Implementation (JI) – Kyoto Protocol

- The mechanism known as "joint implementation," **allows a country with an emission reduction commitment** under the Kyoto Protocol **(Annex B Party)** to earn emission reduction units (ERUs) from **an emission-reduction project in another Annex B Party**, each equivalent to one tonne of CO_2, which can be counted towards meeting its Kyoto target.
- Joint implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer.

Q. Regarding "carbon credits", which one of the following statements is not correct?

a) The carbon credit system was ratified in conjunction with the Kyoto Protocol.
b) Carbon credits are awarded to countries or groups that have reduced greenhouse gases below their emission quota.
c) The goal of the carbon credit system is to limit the increase of carbon emission quota.
d) Carbon credits are traded at a price fixed from time to time by the United Nations Environment Programme.

Explanation:

- Countries bound to Kyoto targets have to meet them largely through domestic action.
- But they can meet part of their targets through "market-based mechanisms".
- The order all goal is to **decrease the carbon emission quota** of the countries.
- Carbon credit prices are traded on an exchange. So, their prices are never fixed.

Answer d)

29.7.5. Non-Compliance of Kyoto and Penalties

- If a country does not meet the requirements for measurements and reporting, the **country loses the privilege of gaining credit through joint implementation projects**.
- If a country goes above its emissions cap and does not try to make up the difference through any of the mechanisms available, then said country must make up the difference plus an **additional thirty percent during the next period**.
- The country could also be **banned** from participating in the **'cap and trade'** program.

29.7.6. Issues with the Flexible Market Mechanisms (Carbon Markets)

- There are no measurable reductions in GHG emissions that can be attributed to carbon markets.
- The two most important carbon markets so far – the **EU Emissions Trading System (EU-ETS)** and the **UN's carbon offsetting scheme**, **Clean Development Mechanism (CDM)** – are failures.
- The EU-ETS power stations and factories have been allocated more allowances (higher quota) than they actually need due to intense industry lobbying.
- There has been a flood of **cheap CDM carbon credits (from China and India)**, which has contributed to the price of carbon being so low that it currently is a negligible cost to industry.
- More importantly, it **does not incentivise investments in low-carbon technologies**.

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- The carbon markets have been infested by corruption and non-transparency. In fact, carbon markets have created a lot of income for consultants, carbon brokers, NGO professionals, etc.

29.7.7. Proposed: Carbon Tax as An Alternative to Carbon Trading

- A carbon tax **imposes a tax on each unit of greenhouse gas emissions** and gives countries/companies an incentive to reduce pollution whenever doing so would cost less than paying the tax.
- Carbon tax is proposed in many developed and developing countries. The proposal has faced severe political resistance (politician – corporate nexus; people fear more burden).

(Proposed) Differential Global Carbon Tax (DGCT)

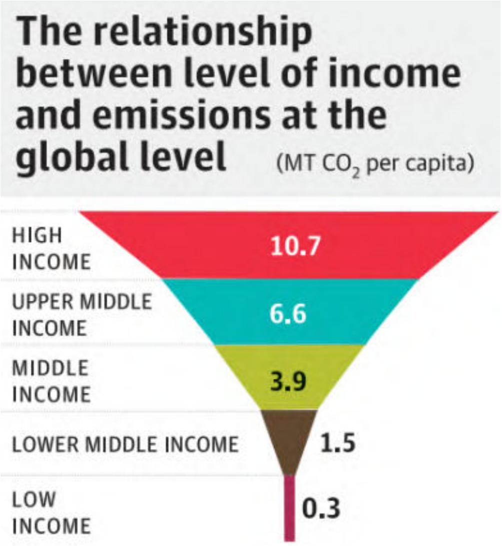
- Similar to "Common but Differentiated Responsibilities" **under Kyoto Protocol**, **DGCT would put higher obligation on countries with higher per capita emissions**.
- Those countries which emit more than the global per capita average would pay a **transition fund** as part of the energy transition of those who are below this average.
- So, those at the **receiving end of climate injustice** are duly compensated and the entire world transitions to greener earth as a result of this process of carbon tax sharing.

(Proposed) Finance Energy Transition (FET – similar to DGCT)

- Currently, the global average of carbon emissions is **4.97 metric tonne per capita**.
- All the countries with emissions above this level (~68 in all) are **payers** to **Finance Energy Transition (FET)** for **beneficiary countries** (135 in number), which are emitting below this level.
- The total amount of **carbon compensation** made by the payer nations would be around $570 billion.
- The distribution of the amount across the payer countries is based on their distance from the global average (i.e., based on how higher their emissions are in comparison to the global average).
- The other side of the same coin is the compensated countries, and the distribution of this fund across them is also based on how lower their emissions are in comparison to the global average.

The Need for A Differential Global Carbon Tax?

- If the emission targets are not met, **tropical regions** of the world (mainly concentrated in the **global South**) are likely to be most negatively affected because of their pre-existing high temperatures.
- Some impact of this was already felt during the Tamil Nadu water crisis in 2019.



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- The **global South, who's historical as well as the present per capita emissions are much lesser than global North**, happens to be at the receiving end of the **lifestyle choices made by the global North**.
- Thus, **the burden of adjustment cannot be equal** when the underlying relationship between the two worlds has been historically unequal (**climate injustice funnel**).
- A just approach would involve a **global sharing of the responsibility among countries according to their respective shares in global emissions**.
- Currently, the most accepted model of mitigating strategy has been the **carbon trading process**.
- However, carbon trading process has its limitations and hence there is a need for an alternate approach such as **differential global carbon tax**.

Is Differential Global Carbon Tax a Globally-Just Policy?

- The two top 'payer' countries in terms of absolute amounts of transfers are the **U.S.** and **China** since their emissions are higher than the global average.
- In terms of 'compensated' countries, India comes at the top due to its population size and its distance from the global emissions' average (**India has per capita emissions of 1.73 metric tonne**).
- The other suspects are all countries from the global South.
- The list springs a few surprises like **France, Sweden,** and **Switzerland**.
- It means that **even high-income countries which have currently kept their per capita emissions low are beneficiaries of this (globally-just) policy**.
- With China in the first list and some of the first world countries in the second, DGCT wants all nations to climb down the emissions ladder. **It is a global green Robin Hood tax**!

Q. Should the pursuit of carbon credit and clean development mechanism set up under UNFCCC be maintained even through there has been a massive slide in the value of carbon credit? Discuss with respect to India's energy needs for economic growth. (2014)

Carbon Tax vs. Carbon Trading (Cap-and-Trade): Which is Better?

Carbon Tax (price instrument)	Carbon Trading (quantity instrument)
• A pure carbon tax **fixes the price of carbon** but **allows the amount of carbon emissions to vary**.	• A pure carbon cap **places a limit on carbon emissions**, letting the **market price of carbon credits vary**.
• A carbon tax directly establishes a price on greenhouse gas emissions. (**One has to pay for every ton of emissions**)	• Carbon Trading program issues a set number of emissions "allowances" each year. (**One has to pay only after they exceed their emissions quota**)
• Carbon tax ensures everyone knows the price being paid for each unit of carbon dioxide emitted, but **uncertainty remains about the actual quantity of emissions**.	• Conversely, cap-and-trade provides **certainty about the quantity of emissions** (it cannot exceed the cap), but **uncertainty about the cost** of achieving these reductions.
• A carbon tax offers stable carbon prices, so energy producers and entrepreneurs can make investment decisions without fear of fluctuating regulatory costs.	• The regulatory costs are always fluctuating and hence making investment decisions is fraught with risks.

- Both policies encourage investors and entrepreneurs to develop new low-carbon technologies.
- Both policies generate government revenue that can be used in productive ways.
- Some economists **recommend a hybrid model** that may offer the best of both worlds.

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- This tends to comprise of a cap on emissions (to **regulate the quantity of pollution**), but with adjustments such as a carbon price floor or ceiling, to **keep the price of a permit within acceptable bounds**.

29.7.8. India Has a Carbon Tax of Sorts

- Budget of 2010-11 introduced a **Clean Energy Cess of Rs. 50 per tonne** on **both domestically produced and imported coal**. Later it was increased to **Rs. 100**.
- With the introduction of the Goods and Service Tax (GST), the **Clean Energy Cess was abolished**.
- A new cess on coal production, called the **GST Compensation Cess of Rs. 400 per tonne** is put in place.
- This cess is used to raise revenues for the **National Clean Energy Fund**.

National Clean Energy Fund (NCEF)

- NCEF is a fund created in 2010-11 for allocation of **Clean Energy Cess (later GST Compensation Cess)** for funding research and innovative projects in **clean energy technologies** of **public sector or private sector** entities, upto the extent of **40% of the total project cost**.
- Assistance is available as a loan or as a viability gap funding, as deemed fit by the Inter-Ministerial group, which decides on the merits of such projects.
- These projects include innovative schemes like **Green Energy Corridor** for boosting up the transmission sector, **Jawaharlal Nehru National Solar Mission (JNNSM)**, etc.
- The Fund is designed as a **non-lapsable fund under Public Accounts** and with its secretariat in Department of Expenditure, Ministry of Finance.

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30. International Environmental Conventions, NGOs and Laws – Part II

30.1. Important UNFCCC Summits Post Kyoto

- After the Kyoto Protocol, parties to the Convention have agreed to further commitments.
- **CMP:** Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol.
- **COP11 / CMP 1** was held in **Montreal, Canada in 2005 (Kyoto Protocol was ratified in 2005)**.

30.1.1. Summits Prior to Paris

Bali (Indonesia) Climate Change Conference 2007 (COP 13; CMP 3)

- COP 13: It is the13th session of the Conference of the Parties to the UNFCCC
- CMP 3: It is the 3rd session of the COP serving as the Meeting of the Parties to the Kyoto Protocol.
- Governments adopted the **Bali Road Map**.
  - ✓ Reaching an agreed outcome and adopting a decision at COP15 in Copenhagen.
  - ✓ The review of the **financial mechanism, going beyond the existing Global Environmental Facility**.

Poznan (Poland) Climate Change Conference 2008 (COP 14; CMP 4)

- It launched the **Adaptation Fund** under the Kyoto Protocol.
- The Fund is financed in part by government and private donors, and also from a **2% share of proceeds of Certified Emission Reductions (CERs) issued under Clean Development Mechanism projects**.

Copenhagen (Denmark) Climate Change Conference 2009 (COP 15; CMP 5)

- The Copenhagen Accord included the **goal of limiting the maximum global average temperature increase to no more than 2 degrees Celsius above pre-industrial levels**, subject to a review in 2015.
- Developed countries promised to provide US$30 billion for the period 2010-2012, and to mobilize long-term finance of a further **US$100 billion a year by 2020** from a variety of sources.

Cancún (Mexico) Climate Change Conference 2010 (COP 16; CMP 6)

- Parties **agreed to commit to a maximum temperature, rise of 2 degrees Celsius above pre-industrial levels**, and **to consider lowering that maximum to 1.5 degrees in the near future**.
- Parties agreed to establish a **Green Climate Fund** to provide financing to projects, programmes, policies and other activities in developing countries via thematic funding windows.
- Governments also agreed to include **carbon capture and storage (CCS)** in the projects under the Clean Development Mechanism (CDM), subject to technical and safety standards.

Durban (Denmark) Climate Change Conference 2011 (COP 17; CMP 7)

- The outcomes included a decision by Parties to adopt a universal legal agreement on climate change as soon as possible, and no later than 2015.
- **Second phase of Kyoto Protocol was secured**.
- **Approved the Governing Instrument for the Green Climate Fund (GCF)**.

Green Climate Fund

- **COP 16 → Decision Made to Establish GCF.**
- **COP 17 → Parties approved the Governing Instrument for the GCF → Legal Approval**
- **COP 18 → Songdo, Incheon, Republic of Korea will host GCF**.

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- The Fund will start operating from 2013.
- It is a mechanism to **redistribute money from the developed to the developing world**.
- GCF will help developing countries financially in adapting mitigation practices to counter climate change.
- It is intended to be the centrepiece of efforts to raise **Climate Finance of $100 billion by 2020**.

Q. Which of the following statements regarding 'Green Climate Fund' is/are correct?

1) It is intended to assist the developing countries in adaptation and mitigation practices to counter climate change.
2) It is founded under the aegis of UNEP, OECD, Asian Development Bank and World Bank

Select the correct answer using the code given below.

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Explanation:

- GCF is founded under the aegis of **UNFCCC COP**

Answer: a) 1 only

Doha (Qatar) Climate Change Conference 2012 (COP 18; CMP 8)

- The conference reached an **agreement to extend the life of the Kyoto Protocol**, which had been due to expire at the end of 2012, until 2020 (**second commitment period 2013 – 2020**).
- The extension of the Kyoto Protocol until 2020 limited in scope to only 15% of the global CO_2 emissions.
- This was due to the lack of participation of **Canada, Japan, Russia, Belarus, Ukraine, New Zealand** and the **United States**. (They all refused to join the second commitment period under the Kyoto Protocol)
- Also, **developing countries like China, India and Brazil** are **not subject to any emissions reductions** under the Kyoto Protocol.
- The conference made little progress towards the funding of the Green Climate Fund.

Warsaw (Poland) Climate Change Conference 2013 (COP 19; CMP 9)

- The conference led to an agreement that all states would start cutting emissions as soon as possible, but preferably by the first quarter of 2015.
- The term **Intended Nationally Determined Contributions** was coined in Warsaw.
- Further the **Warsaw Mechanism** was proposed, which would provide expertise, and possibly aid, to developing nations to cope with loss and damage from such natural extremities as heatwaves, droughts and floods and threats such as rising sea levels and desertification.

Lima (Peru) Climate Change Conference 2014 (COP 20; CMP 10)

- The overarching goal of the conference is to reduce greenhouse gas emissions (GHGs) to **limit the global temperature increase by 2030 to 2 degrees Celsius above 1850 baseline or pre-industrial era**.
- The agreement urged parties to take national pledges by finalizing their **Intended Nationally Determined Contributions (INDC) by November 2015** (before Paris Summit).
- No agreement was reached due to lack of consensus between developed and developing countries.

Developed vs. Developing

- Wealthy nations like the U.S, EU argued that emissions from developing countries are consistently rising and they need to commit to more serious emission cuts.

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- But India accused them of watering down the CDR principle envisaged earlier.
- India stuck to its conventional position that the developed countries should shoulder a bigger burden as they are responsible for the problem in the first place.
- India confirmed that poverty alleviation would continue to be its primary concern and hence it will not compromise with its share of carbon credits.
- Meanwhile, **China agreed a deal in 2014 under which its emissions would peak by 2030** (after 2030, it will start reducing its carbon footprint).
- India, the **world's third largest carbon emitter**, is under pressure to make commitments like China.

30.1.2. Summits Post Paris

Marrakech (Morocco) Climate Change Conference 2016 (COP22; CMP12; CMA1)

- The purpose of the conference was to discuss and implement plans about combatting climate change and to "[demonstrate] to the world that the implementation of the Paris Agreement is underway".
- COP22 was called as "Action COP" or "**Agriculture COP**".
- **Adaptation of African Agriculture (AAA)** was launched at COP 22.
- AAA is promoted by **FAO** along with various governments, especially African countries.

30.2. Paris Climate Change Conference 2015 (COP 21; CMP 11)

- All the major agreements and decisions were reserved for Paris Summit 2015.
- It is most important conference post Kyoto because of the **INDC commitments** made by major polluters.
- The conference's objective is to achieve a **legally binding and universal agreement on climate to be signed in 2015 and implemented by 2020**.
- Prior to the conference, 146 national climate panels publicly presented draft national climate contributions (so-called **Intended Nationally Determined Contributions, INDCs**).
- However, no detailed timetable or country-specific goals for emissions were incorporated into the Paris Agreement – as opposed to the previous Kyoto Protocol.

30.2.1. Paris Agreement

- The conference negotiated the Paris Agreement, a global agreement on the reduction of climate change.
- It entered into force in November **2016** after (ratification by 55 countries that account for at least 55% of global emissions) had been met.
- Signatories: 195 as of 2021; 180+ countries have ratified; **India signed and ratified in 2016**.
  - ⇨ **Ratification:** Once the treaty has been signed, each state will deal with it according to its own national procedures. After approval has been granted under a state's own internal procedures, it will notify the other parties that they consent to be bound by the treaty. This is called ratification.
- The expected key result was an agreement to set a **goal of limiting global warming to "well below 2 °C" Celsius compared to pre-industrial levels**.
- The agreement calls for **zero net anthropogenic greenhouse gas emissions** to be reached during the second half of the 21st century.
- According to the adopted version of the Paris Agreement, the parties will also "**pursue efforts to limit the temperature increase to 1.5 °C**."
- The **1.5 °C goal will require zero emissions sometime between 2030 and 2050**.

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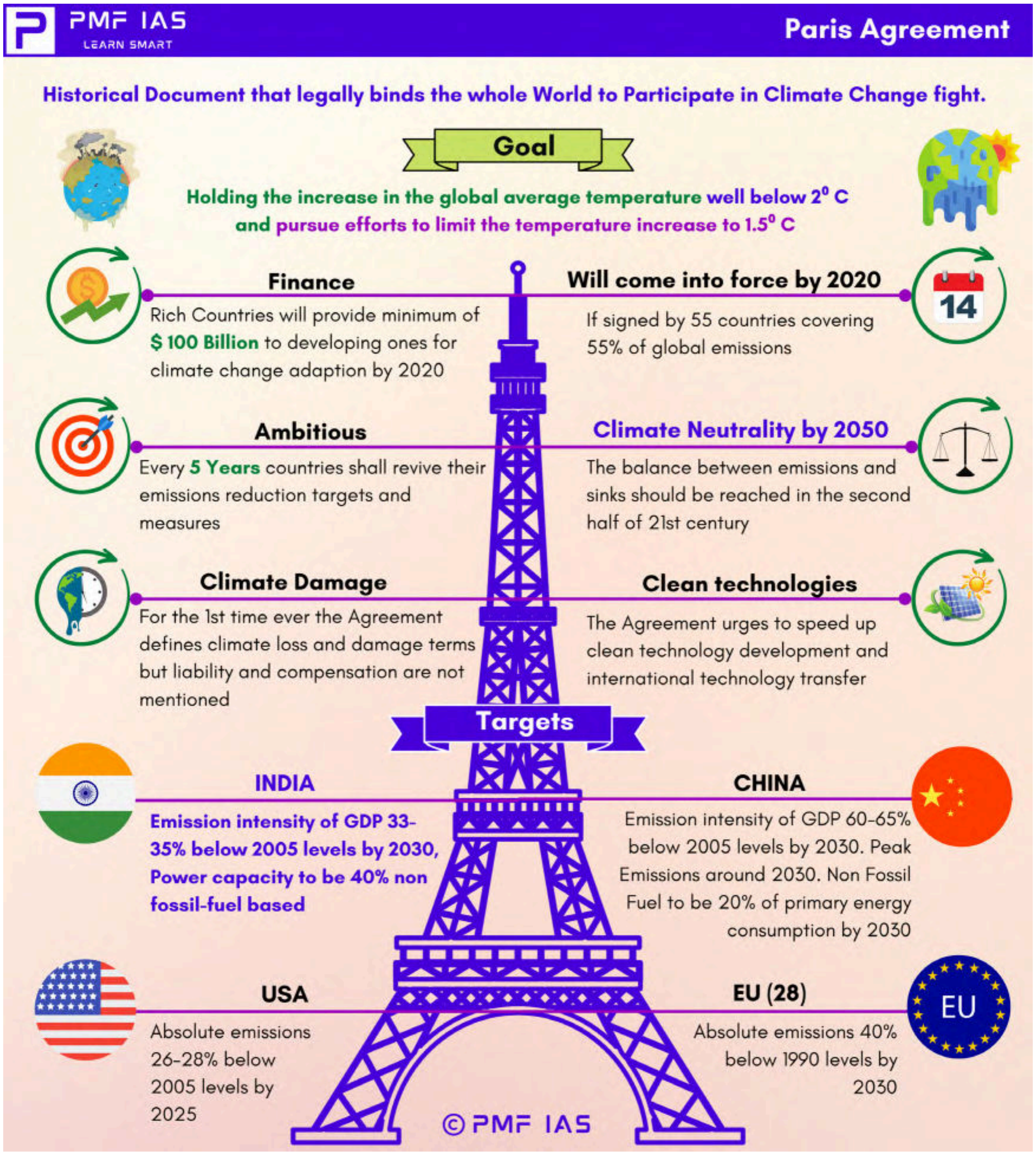
- The developed countries reaffirmed the commitment to mobilize **$100 billion a year** in climate finance by 2020 and agreed to continue mobilizing finance at the level of **$100 billion a year until 2025**.
- In 2017, **United States** announced that the U.S. would cease all participation in the 2015 Paris Agreement on climate change mitigation.
- In accordance with Article 28 of the Paris Agreement, the earliest possible effective withdrawal date by the United States cannot be before November **2020**.
- Thus, The U.S. remained a signatory till November 2020.



30.2.2. Climate Neutral Now

- It was launched by the UNFCCC secretariat in 2015.
- Climate Neutral Now is aiming at encouraging and supporting all levels of society to take climate action to achieve a **climate neutral world by mid-century**, as enshrined in the **Paris Agreement**.
- Climate neutrality is a three-step process, which requires individuals, companies and governments to:
  1. **Measure their climate footprint;**

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2. **Reduce their emissions as much as possible;**
3. **Offset what they cannot reduce with UN certified emission reductions.**

Q. With reference to the Agreement at the UNFCCC Meeting in Paris in 2015, which of the following statements is/are correct? (2016)

1) The Agreement was signed by all the member countries of the UN and it will go into effect in 2017.
2) The Agreement aims to limit the greenhouse gas emissions so that the rise in average global temperature by the end of this century does not exceed 2 °C or even 1.5 °C above pre-industrial levels.
3) Developed countries acknowledged their historical responsibility in global warming and committed to donate $ 1000 billion a year from 2020 to help developing countries to cope with climate change.

Select the correct answer using the code given below.

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

Explanation:

- Paris Agreement entered into force in **November 2016**.

Answer: b) 2 only

Q. Momentum for Change: Climate Neutral Now" is an initiative launched by (2018)

a) The Intergovernmental Panel on Climate Change
b) The UNEP Secretariat
c) The UNFCCC Secretariat
d) The World Meteorological Organisation

Answer: c)

Q. The term 'Intended Nationally Determined Contributions' is sometimes seen in the news in the context of

a) pledges made by the European countries to rehabilitate refugees from the war-affected Middle East
b) plan of action outlined by the countries of the world to combat climate change
c) capital contributed by the member countries in the establishment of Asian Infrastructure Investment Bank
d) plan of action outlined by the countries of the world regarding Sustainable Development Goals

Answer: b)

30.2.3. China-U.S. Deal on Emission Cuts and Pressure on India

- Prior to the summit, China and the United States have agreed on a timetable to limit emission of GHGs.
- **US agreed to reduce by 2025 its emission of GHGs by 26 per cent to 28 per cent below its 2005 level**.
- **China stated its intent to peak emissions of CO_2 in 2030** (from 2030 it will start reducing its emissions).
- It also agreed to raise the **share of non-fossil fuels to 20 per cent in the next 16 years**.
- **India's per capita emissions (1.73 metric tonne)** are estimated at **1/10th of the US** and **1/4th of China**.
- China – US deal imposed a fresh pressure on India to make a voluntary commitment.
- India announced its INDCs at the end of 2015.
- **India**'s **3 targets** under the **Paris Agreement**.

1. **Reduce the emissions intensity of its GDP by 33-35 per cent by 2030, below 2005 levels.**
2. **Achieve 40 per cent of its total electricity capacity from renewables.**

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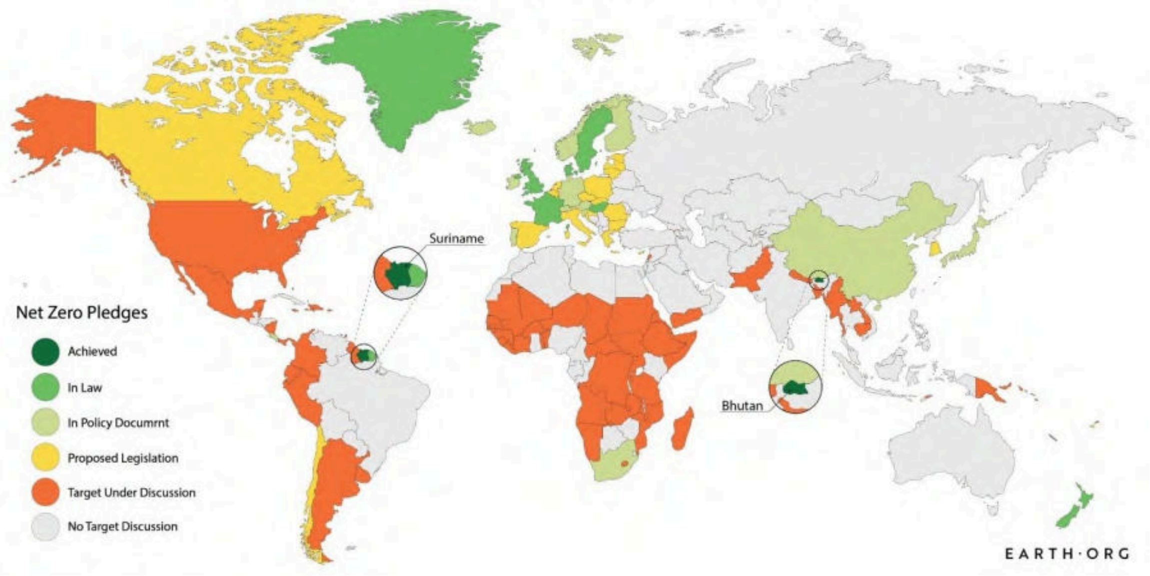
3. Create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 through afforestation by 2030.

30.3. Net Zero Emissions & Carbon Neutrality

- **Net zero** means the amount of **GHGs emitted into the atmosphere is less than the amount taken out**.
- Similarly, **Carbon Neutrality (Net Zero Carbon Footprint)** refers to **achieving net zero CO_2 emissions**.
- The global emissions of greenhouse gases **need to be cut by 45 per cent by 2030** and **become net zero by 2050** to keep **warming below 1.5 °C as decided under the Paris Agreement**.
- For this, the world **must stop using coal** for its energy needs & shift completely towards **renewables**.
- If the 'net zero' target is achieved by 2050 then the world can move to carbon negative trajectory till 2100.
- Some countries have already announced their intention to achieve the net zero target, but the most prominent emitters — **China, US, India** — have so far not done so.

Net zero emissions race



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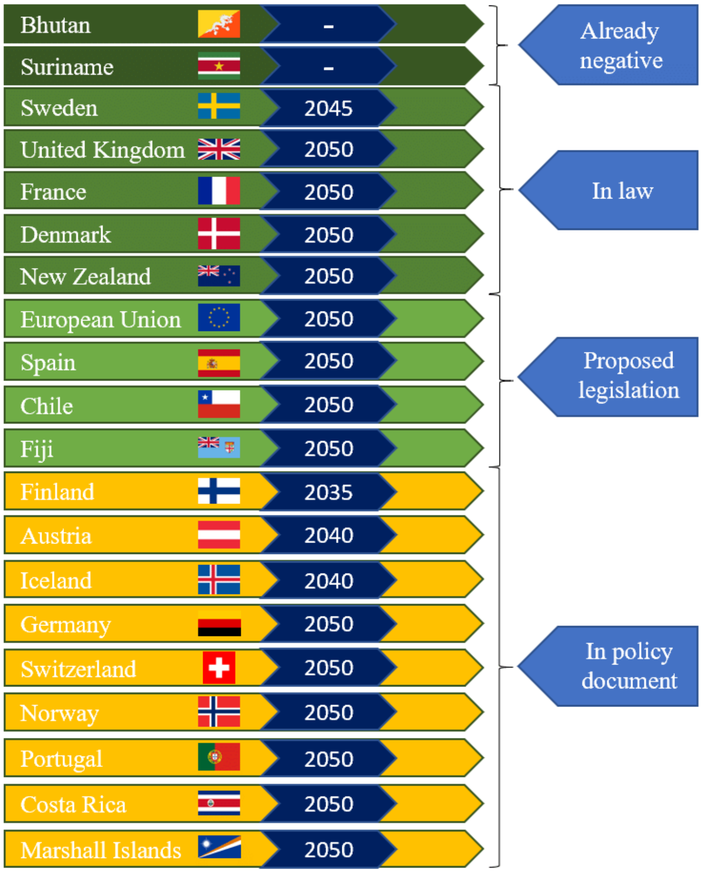

- Of the five developed countries with **national net zero legislation** — **Sweden, Norway, UK, France** and **New Zealand** — **only Sweden aims to become net zero before 2050**.
- **Suriname** and **Bhutan** are the only countries that have achieved **Carbon Neutrality** (**Net Zero Carbon Footprint — GHGs emitted into the atmosphere is less than the amount taken out**).

30.3.1. How Can Net Zero Emissions Be Achieved?

- **Clean coal technology to reduce CO_2 in atmosphere (short-term measure). Carbon sequestration (long-term sustainable measure)**
- **Afforestation: Forests as carbon Sinks (long-term sustainable measure)**
- **Geoengineering to fight climate change (last resort superhuman options)**
- **Electric Mobility and Renewable Energy (prevention is better than cure option)**
- **Carbon Trading & Carbon Tax (long-term measure)**
  - ✓ To contain carbon emissions, UNFCCC summits have arrived at the "**polluter pays**" principle by **placing a price on carbon dioxide and other greenhouse gas emissions**.
  - ✓ The "polluter pays" principle can be implemented either through a **Carbon Tax** or **Carbon Trading**.

30.3.2. European Green New Deal

- **EU is the third-largest emitter** of greenhouse gases in the world after **China** and the **United States**.
- In its climate action plan declared under the **Paris Agreement**, the **EU** was committed to making a **40 per cent reduction in its emissions by 2030 compared to 1990 levels**.
- Through **European Green New Deal**, it is now promising to **increase the 2030 emission reduction target to at least 50 per cent (climate neutrality or zero-emissions by 2050)** and work towards 55 per cent.

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- Even at 40 per cent, the EU had the most ambitious reduction targets among the developed countries.
- The **US**, for example, had agreed to cut emissions by **26-28 per cent by 2030 from 2005 levels**, but having **withdrawn from the Paris Agreement**, it is under **no obligation to fulfil even that target**.

30.3.3. India's Objection to Net Zero

- Basic argument by India is that **net zero goals do not figure in the 2015 Paris Agreement**.
- Paris Agreement only requires every signatory to take **best climate action it can (INDC)**.
- Most of the countries have submitted targets for the 2025 or 2030 period.

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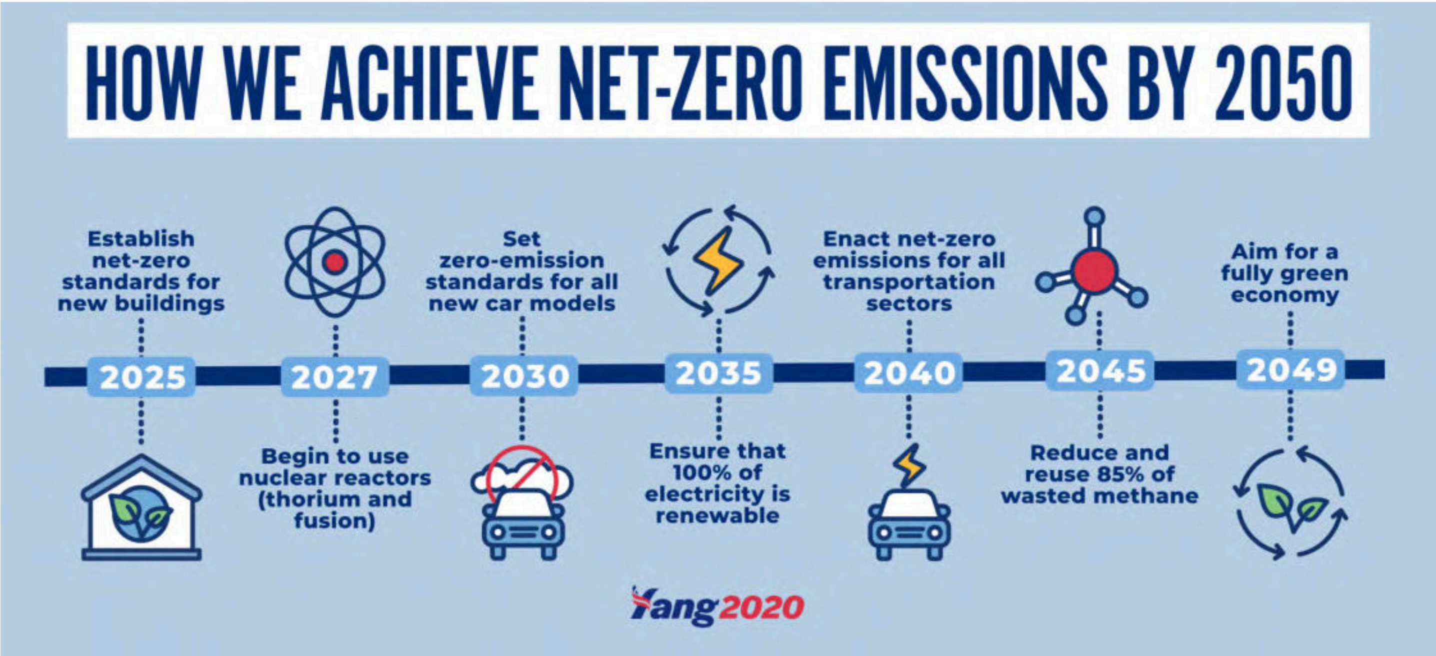

- Developed countries have not delivered on their past commitments.
- Most of them are not in line to achieve Paris Agreement targets.
- India argues that instead of opening up parallel discussion on net zero targets outside of Paris Agreement, **countries must focus on delivering what they have already promised**.
- India as a developing country needs to **achieve higher economic growth**.
- Most of the **carbon removal technologies** are **unreliable or very expensive**.
- With increase in India's growing energy demands **net zero emissions in immediate future is impossible**.
- **India** is already well on its way to over-achieve its **3 targets** under the **Paris Agreement**.

1. **Reduce the emissions intensity of its GDP by 33-35 per cent by 2030, below 2005 levels.**
2. **Achieve 40 per cent of its total electricity capacity from renewables.**
3. **Create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 through afforestation by 2030.**

30.4. Intended Nationally Determined Contributions (INDC)

- During **Warsaw Summit 2013 (COP 19)**, countries agreed to publicly outline **what actions they intend to take under a global agreement well before the Paris Summit 2015**.
- These country commitments are known as **Intended Nationally Determined Contributions (INDCs)**.

30.4.1. The main points of contention on INDCs

Inclusion of Adaptation, finance & transfer of technology

- Developed countries are of the view that only actions that help in **reducing greenhouse gas emissions** should be counted as 'contributions' in INDCs.
- Almost every developing country, however, wants **adaptation measures** also to be counted.
- Developing countries also want efforts by developed ones on **providing money or transferring technology** to poorer nations to be included in INDCs.
- This will help in holding the rich countries (biggest culprits that contributed to the increase of GHG emissions since Industrial Revolution) accountable to their promises on ensuring financial and technology flows.

Commitment Period

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- India, European Union, China etc. are in favour of a 10-year commitment period.
- The United States, however, wants five-year commitment period so that countries can make quicker reviews.

Ex-post Review

- Since the INDCs are **'nationally-determined' and voluntary**, the level of ambition in making 'contributions' is likely to be low.
- Some countries want an assessment of each country's INDC to see whether these are in line with the global 2-degree target.
- India and the United States strongly resent any such provision, saying such an exercise will negate the 'nationally-determined' nature of the 'contributions'.

30.4.2. India's INDC objectives

- Announced in October 2015 (Lima summit urged every country to announce its INDCs by Nov 2015)
- **Reduce emission intensity by 33 to 35 per cent by 2030 compared to 2005 levels**.

How can the emission reduction target be achieved?

- Introduce new, more efficient, and **cleaner technologies** in **thermal power generation**.
- Reducing emissions from transportation sector.
- Promote energy efficiency, mainly in industry, transportation, buildings and appliances.
- Develop climate resilient infrastructure.
- **Pursue Zero Effect, Zero Defect policy** under Make in India programme.
- **Produce 40 per cent of electricity from non-fossil fuel-based energy resources by 2030**, if international community helps with technology transfer and low cost finance.

How can the renewable target be acheived?

- Install **175 GW of solar, wind and biomass electricity by 2022**, and scale up further in following years.
- Aggressively pursue development of hydropower.
- Achieve the target of **63 GW of installed nuclear power capacity by 2032**.
- Create an **additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent by 2030** through additional forest and tree cover.

How can the afforestation target be achieved?

- Full implementation of **National Afforestation Programme (NAP) scheme, National Mission for a Green India (GIM) (Green India Mission)** and other programmes of afforestation.
- Develop 1,40,000 km long tree line on both sides of national highways.
- Sustainable development.
- Develop robust adaptation strategies for agriculture, water and health sectors.

How to augment the water resource?

- **Redesign National Water Mission** and **National Mission on Sustainable Agriculture**.
- Active implementation of ongoing programmes like **National Initiative on Climate Resilient Agriculture**, setting up of 100 mobile soil-testing laboratories, distribution of soil health cards to farmers.
- Additional impetus on watershed development through **Neeranchal scheme**.
- Effective implementation of **National Mission on Clean Ganga**.
- Early formulation and implementation of **National Health Mission**.

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- Complete **Integrated Coastal Zone Management plan**. Mapping and demarcation of coastal hazard lines.

30.4.3. Money required to meet India's INDC

- At least USD 2.5 trillion is required between 2015 and 2030 to implement all planned actions.
- **Cess on coal** is being used for funding clean energy projects through **National Adaptation Fund**.
- **Tax free infrastructure bonds** were introduced for funding renewable energy projects.

Tax free infrastructure bonds

- A bond is an instrument to borrow money. Infrastructure bonds are borrowings to be invested in government funded infrastructure projects.
- They are issued by governments/authorized Infrastructure companies/Non-Banking Financial Companies.
- Investments up to Rs. 20000 are eligible for income tax deduction under the Income Tax Act.

National Adaptation Fund on Climate Change (NAFCC)

- Budget 2015 introduced "**National Adaptation Fund**" for climate change.
- As an initial sum, an amount of Rs 100 crore will be transferred to the Fund.
- Budget provision for the year 2015-16 and 2016-17 is Rs.350 crores.
- **Money obtained from coal cess goes into NAFCC**.
- Objective: **Assist States and Union Territories** that are **particularly vulnerable to the adverse effects of climate change** in meeting the cost of adaptation.
- The **National Bank for Agriculture and Rural Development (NABARD)** has been appointed as National Implementing Entity (NIE) responsible for implementation of adaptation projects under the (NAFCC).
  - ⇨ **National Clean Energy Fund (NCEF) ➔ funds technology**
  - ⇨ **National Adaptation Fund ➔ funds adaptation**

30.5. Others

30.5.1. UN-REDD and REDD+

UN-REDD	REDD+
• The **United Nations Programme** on **Reducing Emissions from Deforestation and Forest Degradation (UN-REDD)**. • Headquarters: Geneva, Switzerland. • Membership: 64 Partner Countries.	• **Reducing emissions from deforestation and forest degradation** • **Role of conservation, sustainable management of forests** • **Enhancement of forest carbon stocks** in **developing countries**
• It is a multilateral **collaborative programme** of the ✓ **Food and Agriculture Organization (FAO) of the UN**, ✓ **United Nations Development Programme (UNDP)** and ✓ **United Nations Environment Programme (UNEP)** • It was created in 2008 in response to the **UNFCCC** decisions on the **Bali Action Plan** and REDD at COP-13.	• **Voluntary climate change mitigation approach** that has been **developed by Parties to the UNFCCC**.
• It partners with **developing countries** to support them in establishing the technical capacities needed to implement **REDD+** and meet UNFCCC requirements for REDD+ results-based payments.	• REDD+ goes beyond simply deforestation and forest degradation. • It aims to incentivize developing countries to reduce emissions from deforestation and forest degradation, **conserve forest carbon stocks**, sustainably manage forests and enhance forest carbon stocks.

- In addition to the **UN-REDD Programme**, other initiatives assisting countries that are engaged in REDD+ include the **World Bank's Forest Carbon Partnership Facility**, the **Global Environment Facility**, the **Green Climate Fund** etc.

Q. Proper design and effective implementation of UN-REDD+ Programme can significantly contribute to

1) protection of biodiversity

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2) resilience of forest ecosystems
3) poverty reduction

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

Explanation:

- Poverty reduction is nowhere mentioned in the REDD+. But the question is not asking for specific details, "UN-REDD+ Programme **can significantly contribute to?**"
- **Conservation, sustainable management of forests** and **enhancement of forest carbon stocks** in developing countries will certainly contribute to employment opportunities and help in poverty reduction.
- According to FAO, REDD+ can also contribute to achieving other SDGs – including those which address **poverty reduction, health and well-being, hunger alleviation**, and improving institutions"

Answer: a) 1, 2 and 3 (UPSC Official Key)

30.5.2. Forest Carbon Partnership Facility

- It is a **global partnership** of governments, businesses, civil society, and Indigenous Peoples focused on reducing emissions from activities commonly referred to as **REDD+**
  - ✓ **deforestation and forest degradation,**
  - ✓ **forest carbon stock conservation,**
  - ✓ **the sustainable management of forests, and**
  - ✓ **the enhancement of forest carbon stocks in developing countries.**
- The **World Bank** assumes the functions of trustee and secretariat.
- The **World Bank**, the **Inter-American Development Bank** and **United Nations Development Programme (UNDP)** are delivery partners under the **Readiness Fund** and **responsible for providing REDD+ readiness support**.

Objectives

- To assist **countries** in their REDD+ efforts by providing them with **financial** and **technical assistance**.
- To pilot a performance-based payment system for REDD+ activities.
- To test ways to sustain or enhance livelihoods of local communities and to conserve biodiversity.
- To disseminate broadly the knowledge gained in Emission Reductions Programs (ERPs).

30.5.3. BioCarbon Fund Initiative

- The **BioCarbon Fund Initiative for Sustainable Forest Landscapes (ISFL)** is a **multilateral fund**, supported by **donor governments** & **managed by the World Bank**.
- It seeks to **promote reduced greenhouse gas emissions** from the land sector, from deforestation and forest degradation in developing countries (**REDD+**), and from sustainable agriculture, as well as smarter land-use planning, policies, and practices.

30.5.4. Climate and Clean Air Coalition (CCAC)

- In 2012, a few nations, along with the **United Nations Environment Programme (UNEP)**, came together to form the **Climate & Clean Air Coalition**.

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- It is a **partnership** of governments, public and private sector, scientific institutions, civil society organizations, etc. committed to protecting the climate through actions to **reduce short-lived climate pollutants**.

Short-lived climate pollutants (SLCPs)

- SLCPs have relatively short lifetime in the atmosphere – **a few days to a few decades**.
- Though short-lived, their potential to warm the atmosphere can be many times greater than CO_2.
- SLCPs are responsible for up to 45% of current global warming, only next to CO_2.
- SLCPs include black **carbon, methane, tropospheric ozone**, and **hydrofluorocarbons**.

Benefits of Reducing SLCPs

- Reducing methane & black carbon could prevent crop losses.
- Reducing SLCPs could slow down the warming expected by 2050 by about 0.5 °C.
- SLCPs play an important role in achieving the **2° C target set by the Paris Agreement**.

Cool Coalition

- It aims to inspire ambition and accelerate action on the transition to **clean and efficient cooling**.
- It was launched at the first **Global Conference on Synergies** between the 2030 Agenda and Paris Agreement in 2019.
- It is a global effort led by:
  1. **UN Environment Programme**
  2. **Climate and Clean Air Coalition**
  3. **Kigali Cooling Efficiency Program**
  4. **Sustainable Energy for All (SEforALL)**

30.5.5. Global Climate Change Alliance + (GCCA+)

- **GCCA+** is a **European Union** initiative.
- It helps **vulnerable countries** on the front line of climate change.
- GCCA+ initiatives help mainly **Small Islands Developing States (SIDS)** and **Least Developed Countries (LDCs)** increase their resilience to climate change.
- It also supports these group of countries in implementing their commitments resulting from the **2015 Paris Agreement** on Climate Change (COP21).

30.5.6. Global Alliance for Climate-Smart Agriculture (GACSA)

- GACSA is promoted by **FAO** along with various governments.
- Its vision is to improve food security, nutrition and resilience in the face of climate change.
- GACSA works towards three aspirational outcomes to:
  1. **Improve farmers' agricultural productivity and incomes in a sustainable way;**
  2. **Build farmers' resilience to extreme weather and changing climate;**
  3. **Reduce greenhouse gas emissions associated with agriculture, when possible.**

30.5.7. GHG Protocol

- GHG Protocol is developing standards, tools and online training that helps countries, cities and companies track progress towards their climate goals.
- GHG Protocol establishes frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions.

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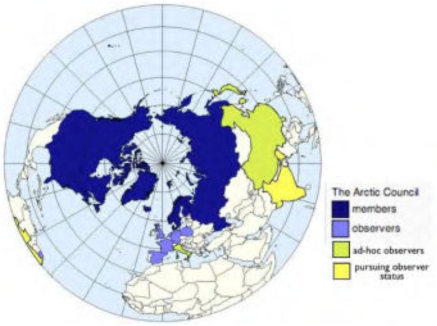
- GHG Protocol arose when **World Resources Institute (WRI)** and **World Business Council for Sustainable Development (WBCSD)** recognized the need for an international standard for **corporate GHG accounting** and reporting in the late 1990s.

30.5.8. Arctic Council



- Arctic Council is an **intergovernmental forum** promoting cooperation, coordination and interaction among the Arctic states, Arctic Indigenous communities and other Arctic inhabitants on **common Arctic issues**, in particular on issues of sustainable development and environmental protection in the Arctic.
- The Arctic Council consists of the **eight Arctic States**: **Canada, the Kingdom of Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, Russia, Sweden** and the **United States**.

Q. With reference to 'Forest Carbon Partnership Facility', which of the following statements is/are correct?

1) It is global partnership of governments, businesses, civil society and indigenous peoples.
2) It provides financial aid to universities, individual scientists and institutions involved in scientific forestry research to develop eco-friendly and climate adaptation technologies for sustainable forest management.
3) It assists the countries in their 'REDD+ (Reducing Emission from Deforestation and Forest Degradation+)' efforts by providing them with financial and technical assistance.

Select the correct answer using the code given below

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation

- It provides financial incentives to countries in their REDD+ efforts. There is no mention of assistance to universities, scientists…

Answer: c) 1 and 3 only

Q. 'BioCarbon Fund Initiative for Sustain-able Forest Landscapes' is managed by the

a) Asian Development Bank
b) International Monetary Fund
c) United Nations Environment Programme
d) World Bank

Q. With reference to 'Global Climate Change Alliance', which of the following statements is/are correct?

1) It is an initiative of the European Union.
2) It provides technical and financial support to targeted developing countries to integrate climate change into their

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development policies and budgets.

3) It is coordinated by World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).

Select the correct answer using the code given below:

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: a) 1 and 2 only

Q. Consider the following countries:

1) Denmark
2) Japan
3) Russian Federation
4) United Kingdom
5) United States of America

Which of the above are the members of the 'Arctic Council'?

a) 1, 2 and 3
b) 2, 3 and 4
c) 1, 4 and 5
d) 1, 3 and 5

Answer: d)

Q. What is 'Greenhouse Gas Protocol'? (2016)

a) It is an international accounting tool for government and business leaders to understand, quantify and man-age greenhouse gas emissions
b) It is an initiative of the United Nations to offer financial incentives to developing countries to reduce green-house gas emissions and to adopt eco-friendly technologies
c) It is an inter-governmental agreement ratified by all the member countries of the United Nations to reduce greenhouse gas emissions to specified levels by the year 2022
d) It is one of the multilateral REDD+ initiatives hosted by the World Bank

Answer: a)

Q. With reference to the 'Global Alliance for Climate Smart Agriculture (GACSA)', which of the following state-ments is/are correct? (2018)

1) GACSA is an outcome of the Climate Summit held in Paris in 2015.
2) Membership of GACSA does not create any binding obligations.
3) India was instrumental in the creation of GACSA.

Select the correct answer using the code given

a) 1 and 3 only
b) 2 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: 2) only

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31. National Environmental Legislation – Part I

- Our constitution, originally, did not contain any direct provisions regarding the protection of natural environment.
- However, after the **United Nations Conference on Human Environment, held in Stockholm in 1972**, Indian constitution was amended to include **protection of the environment as a constitutional mandate**.
- Environment related legislation came very late in **1972** with **Wild Life Protection Act 1972**.
- The **forty second amendment (Fundamental Duties)** Clause (g) to Article 51A of the Indian constitution made it a **fundamental duty** to protect and improve the natural environment.
- **Amendment Clause (g) to Article 51A** of the Indian constitution states "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and have compassion for living creatures."
- There is a directive, given to the State as one of the **Directive Principles of State Policy** regarding the protection and improvement of the environment.
- **Article 48A** states "The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country".
- **Article 21 of the Indian Constitution** assures the citizens of India the **right to a healthy environment**.
- The **Department of Environment** was established in India in **1980** to ensure a healthy environment for the country. This later became the **Ministry of Environment and Forests (MoEF) in 1985**.
- It is now the **Ministry of Environment, Forests and Climate Change (MoEFCC)** since 2014.
- **The Environment Protection Act of 1986 (EPA)** came into force soon after the **Bhopal Gas Tragedy** and is considered **umbrella legislation** as it fills many lacunae in the existing legislations.

31.1. Pollution Related Laws

31.1.1. The Water (Prevention and Control of Pollution) Act of 1974 and Amendment, 1988

- The Act vests regulatory authority in **State Pollution Control Boards** to **establish and enforce effluent standards for factories**.
- A **Central Pollution Control Board** performs the same functions for Union Territories and formulates policies and **coordinates activities of different State Boards**.
- The Act grants power to SPCB and CPCB to test equipment and to take the sample for the purpose of analysis.
- Prior to its amendment in 1988, enforcement under the Act was achieved through criminal prosecutions initiated by the Boards.
- The **1988 amendment act empowered SPCB and CPCB to close a defaulting industrial plant**.

Central Pollution Control Board (CPCB)

- CPCB is a **statutory body** constituted under the Water (Prevention and Control of Pollution) Act, 1974.
- Further, **CPCB was entrusted** with the powers and functions under the **Air (Prevention and Control of Pollution) Act, 1981**.
- It provides technical services to the MOEF of the provisions of the **Environment (Protection) Act, 1986**.
- Principal Functions of the CPCB:
  - ✓ to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and
  - ✓ to **improve the quality of air** and to prevent, control or abate air pollution in the country.

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- CPCB oversees the **National Air Monitoring Programme (NAMP)** and Water Quality Monitoring (WQM).

31.1.2. The Water (Prevention and Control of Pollution) Cess Act of 1977

- The Water Cess Act was passed to **generate financial resources** to meet **expenses of the Central and State Pollution Boards**.
- The Act creates economic incentives for pollution control and requires local authorities and certain designated industries to pay a **cess (tax) for water effluent discharge**.
- The Central Government, after deducting the expenses of collection, pays the central and state boards such sums, as it seems necessary.
- To encourage capital investment in pollution control, the Act gives a polluter a 70% **rebate of the applicable cess upon installing effluent treatment equipment**.

31.1.3. The Air (Prevention and Control of Pollution) Act of 1981 and amendment, 1987

- To implement the decisions taken at the United Nations Conference on the Human Environment held at Stockholm in June 1972, Parliament enacted the nationwide Air Act.
- The main objectives of this Act are to improve the quality of air and to prevent, control and abate air pollution in the country.

Important provisions of this Act

- The Air Act's framework is **similar to that of the Water Act of 1974**. The Air Act **expanded the authority** of the **central and state boards** established under the Water Act, **to include air pollution control**.
- States not having water pollution boards were required to set up air pollution boards.
- Under the Air Act, all industries operating within designated **air pollution control areas** must obtain **consent (permit) from the State Boards**.
- The **states** are required to prescribe emission standards for industry and automobiles **after consulting the central board** and noting its ambient air quality standards.
- The Act grants power to **SPCB** and to test equipment and to take the sample for the purpose of analysis from any chimney, fly ash or dust or any other.
- Prior to its amendment in 1988, enforcement under the Act was achieved through criminal prosecutions initiated by the Boards.
- The 1988 amendment act empowered SPCB and CPCB to close a defaulting industrial plant.
- Notably, the 1987 amendment introduced a **citizen's suit provision** into the Air Act and extended the Act to include **noise pollution**.

31.2. Environment (Protection) Act of 1986 (EPA, 1986)

- In the wake of the **Bhopal tragedy**, the government of India enacted the **Environment Act of 1986**.
- It is one of the most comprehensive legislations with pretext to protection & improvement of environment.
- The 1986 Act was general legislation enacted **under Art. 253.**
  - ✓ **Art. 253:** **Parliament has power to make law** for whole or any part of territory of India **for implementing any treaty, convention, agreement** with any country or countries or any decision made at any international conference, association.

31.2.1. The Objectives of EPA

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- The purpose of the Act is to implement the decisions of the **United Nations Conference on the Human Environment of 1972**.
- The Act is an "**umbrella**" for legislations designed to provide a framework for **Central Government**, coordination of the activities of various central and state authorities established under previous Acts, such as the **Water Act** and the **Air Act**.
- The decisions relate to the protection and improvement of the human environment & the prevention of hazards to human beings, other living creatures, plants and property.
- **The act defined:**
  - ✓ **"Environment" defined** to **include water, air and land and the inter-relationships** which exist among water, air and land and human beings and other living creatures, plants, micro-organisms and property.
  - ✓ "**Environmental pollution**" is the presence of pollutant, defined as any solid, liquid or gaseous substance present in such a concentration as may be or may tend to be injurious to the environment.
  - ✓ "**Hazardous substances**" include any substance or preparation, which may cause harm to human beings, other living creatures, plants, microorganisms, property or the environment.

31.2.2. The main provisions of the Act

- Through this Act **Central Government gets full power** for the purpose of protecting and improving the quality of the environment.
- **By virtue of this Act**, Central Government has armed itself with considerable powers which include,
  - ✓ Coordination of action by state,
  - ✓ Planning and execution of nationwide programmes,
  - ✓ Laying down environmental quality standards, especially those governing emission or discharge of environmental pollutants.
  - ✓ Placing restriction on the location of industries and so on.
  - ✓ Authority to issue direct orders, included orders to close, prohibits or regulate any industry.
  - ✓ Power of entry for examination, testing of equipment and other purposes and power to analyse the sample of air, water, soil or any other substance from any place.
  - ✓ Preparation of codes, guides & manuals.
  - ✓ Such other matters as **central government deems necessary** or expedient for purpose of securing the effective implementation of act **(this provision truly makes it an umbrella legislation)**.
- The Act explicitly prohibits discharges of environmental pollutants in excess of prescribed regulatory standards.
- There is also a specific prohibition against **handling hazardous substances** except those in compliance with regulatory procedures and standards.
- The Act provides **provision for penalties.** For each failure or contravention, the punishment included a **prison term up to 5 years** or fine up to Rs. 1 lakh, or both.
  - ✓ The Act imposed an additional fine of up to Rs. 5,000 for every day of continuing violation.
  - ✓ If a failure or contravention occurs for more than one year, offender may be **punished with imprisonment** which may be **extended to 7 years.**
- **Section 19** provides that **any person**, in addition to authorized government officials, may **file a complaint with a court** alleging an offence under the Act.
- This "**Citizens' Suit**" provision requires that the person has to give notice of **not less than 60 days** of the alleged offence of pollution to the Central Government.

Q. Consider the following statements: The Environment Protection Act, 1986 empowers the Government of India

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to

1. State the requirement of public participation in the process of environmental protection, and the procedure and manner in which it is sought.
2. Lay down the standards for emission or discharge of environmental pollutants from various sources.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: b) 2 only

31.2.3. Rules for Hazardous Microorganisms/Genetically Engineered Organisms or Cells 1989

- Aim of 'Rules 1989' is to protect environment, nature, and health (**biosafety**) in connection with application of **gene technology and micro-organisms**.
- These rules cover areas of research as well as large scale applications of **GMOs** and their products including experimental field trials and seed production.
- The Rules 1989 also define the competent authorities and composition of such authorities for handling of various aspects of the Rules.

Presently there are six committees:

1. **Recombinant DNA Advisory Committee (RDAC):** The functions are of an advisory nature. It recommends safety regulations for India in recombinant research, use and applications.
2. **Review Committee on Genetic Manipulation (RCGM)** established under the Department of Biotechnology, Ministry of Science and Technology, to monitor the safety related aspects in respect of on-going research projects.
3. **Genetic Engineering Appraisal Committee (GEAC)**: it is the **statutory body** constituted in the **MoEF** under 'Rules 1989', under the **Environment Protection Act, 1986**.
4. **State Biotechnology Coordination Committee (SBCC's)** have a major role in monitoring. It also has powers to inspect, investigate and take punitive action in case or violations of statutory provisions.
5. **District Level Committees (DLCs)** have a major role in monitoring the safety regulations in installations engaged in the use of GMOs/hazardous microorganisms and its applications in the environment.
6. **Institutional Biosafety Committee (IBSC)** is established under the institution engaged in GMO research to oversee such research and to interface with the RCGM in regulating it.

Q. The Genetic Engineering Appraisal Committee is constituted under the

a) Food Safety and Standards Act, 2006
b) Geographical Indications of Goods (Registration and Protection) Act, 1999
c) Environment (Protection) Act, 1986
d) Wildlife (Protection) Act, 1972

Answer: c) EPA

31.2.4. National Ganga Council or NRGBA

- **National Ganga Council** was set up in **2016** under **Environment Protection Act, 1986** as **National Council for Rejuvenation, Protection & Management of River Ganga (NRGBA)**.
- It dissolved **National Ganga River Basin Authority (NGRBA)**.

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- **Jurisdiction:** Ganga & Its Tributaries
- It is headed by the **Prime Minister**.

Erstwhile National Ganga River Basin Authority (NGRBA)

- National Ganga River Basin Authority (NGRBA) was a financing, planning, implementing, monitoring and coordinating authority for the Ganges River, functioned under the **Ministry of Water Resources**.
- The mission of the organization was to safeguard the drainage basin which feeds water into the Ganges by **protecting it from pollution or overuse.**
- It was established by the Central Government of India, **in 2009** under Section 3(3) of the **Environment Protection Act, 1986**, which also declared Ganges as the **'National River' of India**.

Composition of NGRBA

- The **Prime Minister** chaired the authority.

Other Members:

- Minister of Environment and Forests (Union Minister)
- Chief Ministers of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal.

Q. Which of the following are the key features of 'National Ganga River Basin Authority (NGRBA)'? (2016)

1) River basin is the unit of planning and management.
2) It spearheads the river conservation efforts at the national level.
3) One of the Chief Ministers of the States through which the Ganga flows becomes the Chairman of NGRBA on rotation basis.

Select the correct answer using the code given Below.

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: a) 1 and 2 only

31.3. Environmental Impact Assessment (EIA)

- EIA is a tool to **anticipate the likely environmental impacts** that may arise out of the proposed developmental activities and **suggest mitigation measures and strategies**.
- EIA was introduced in India in **1978**, with respect to **river valley projects**.
- Later the EIA legislation was enhanced to include other developmental sections.
- EIA comes under **Notification on Environmental Impact Assessment (EIA) of developmental projects 1994** under the provisions of **Environment (Protection) Act, 1986**.
- Besides EIA, the Government of India under **Environment (Protection) Act 1986** issued a number of other notifications, which are related to environmental impact assessment.
- EIA is now mandatory for more than 30 categories of projects, and these projects get **Environmental Clearance(EC)** only after the EIA requirements are fulfilled.
- **Environmental clearance** or the **'go ahead'** signal is granted by the **Impact Assessment Agency** in the **Ministry of Environment and Forests**, Government of India.
- The important aspects of EIA are:
  - ✓ **risk assessment,**

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- ✓ **environmental management** and
- ✓ **post product monitoring.**

- All projects that require clearance from central government can be broadly categorized into the following:
  1. Individual projects that need require clearance from central government,
  2. Nuclear power and related projects,
  3. River valley projects including hydel power, major irrigation and flood control,
  4. Ports, harbours, airports (except minor ports and harbours),
  5. Petroleum refineries including crude and product pipelines,
  6. Chemical fertilizers and pesticides,
  7. Petrochemical complexes and petrochemical intermediates and production of basic plastics,
  8. Bulk drugs and pharmaceuticals,
  9. Exploration for oil and gas and their production, transportation and storage,
  10. Synthetic rubber,
  11. Asbestos and asbestos products,
  12. Hydrocyanic acid and its derivatives,
  13. Primary metallurgical industries (such as production of iron and steel, aluminium, copper, zinc, lead, and ferro-alloys),
  14. Chlor-alkali industry,
  15. Integrated paint complex including manufacture of resins and basic raw materials required in the manufacture of paints,
  16. Viscose staple fibre (biodegradable fibre similar to cotton) and filament yarn,
  17. Storage batteries integrated with manufacture of oxides of lead and lead antimony alloy,
  18. All tourism projects between 200m-500 metres of High Water Line and at locations with an elevation of more than 1000 metres with investment of more than Rs. 5 crores,
  19. Thermal power plants,
  20. Mining projects (with lease more than 5 hectares),
  21. Highway projects except projects relating to improvement work provided it does not pass through ecologically sensitive areas such as National Parks, Sanctuaries, Tiger Reserves, Reserve Forests,
  22. Tarred roads in the Himalayas and forest areas,
  23. Distilleries,
  24. Raw skins and hide,
  25. Pulp, paper and newsprint, dyes,
  26. Cement,
  27. Electroplating,
  28. Meta aminophenol, etc.

31.3.1. EIA Process and Procedures

- **Steps in EIA process (EIA process is cyclical with interaction between the various steps):**
  - ✓ **Screening:** The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
  - ✓ **Scoping:** The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring needs to be worked out.
  - ✓ **Collection of baseline data:** Baseline data is the environmental status of study area.

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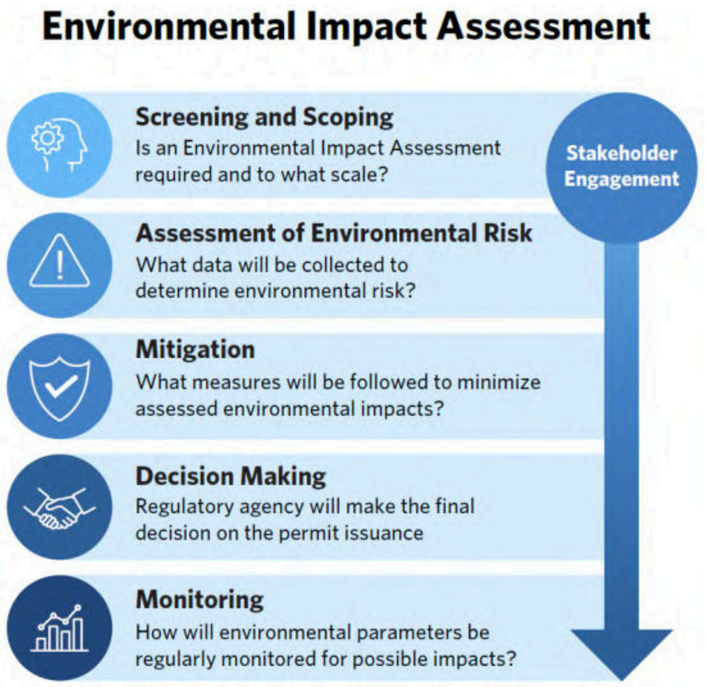
- ✓ **Impact prediction:** Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted.
- ✓ **Mitigation measures:** The EIA report should include the actions and steps for preventing, minimizing or by passing the impacts or else the level of compensation for probable environmental damage or loss.
- ✓ **Public hearing:** On completion of the EIA report, public and environmental groups living close to project site may be informed and consulted.
- ✓ **Decision making: Impact Assessment Authority** along with the experts consult the project-in-charge to take the final decision, keeping in mind EIA and EMP (Environment Management Plan).
- ✓ **Monitoring and implementation of environmental management plan**
- ✓ **Assessment of Alternatives, Delineation of Mitigation Measures and EIA Report**
- ✓ **Mitigation plan:** Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP).
- ✓ **Risk assessment:** Inventory analysis and hazard probability and index also form part of EIA procedures.



Environment Management Plan

- Delineation of mitigation measures including prevention and control for each environmental component and rehabilitation and resettlement plan.

Environmental Appraisal

- An **Appraisal Committee** constituted by the **Ministry of Environment and Forests** will first scrutinized a project based on the data presented by the project authorities.
- If necessary, the MoEF may also hold consultations with the investors and experts on specific issues as and when necessary.
- After considering all the facets of a projects, environmental clearance is accorded subject to implementation of the stipulated environmental safeguards.
- In case of projects where the project proponents have submitted complete information, a decision is taken **within 90 days**.

EIA of Coasts

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- **Coastal Zone Management Plans (CZMPs)** are prepared by coastal states or Union Territories as per rules set by CRZ notification.
- CZMPs are prepared based on identification and categorization of coastal areas for different activities and then submitted to the MoEF for approval.

Single window clearance

- **Environmental clearance + Forestry clearance**.
- When a project requires **both environmental clearance** as well as approval under the **Forest (Conservation) Act, 1980**, proposals for both are required to be given simultaneously.
- The processing is done simultaneously for clearance or rejection.
- If the project does not involve diversion of forestland, the case is processed only for environmental clearance.

The Main Participants Of EIA

- EIA applies to public and private sections. The six main players are:
  1) Those who propose the project.
  2) The environmental consultant who prepares EIA on behalf of project proponent.
  3) **Pollution Control Board (State or National)**.
  4) **Public has the right to express their opinion**.
  5) The **Impact Assessment Agency**.
  6) Regional centre of the MoEF.

31.3.2. Composition of the expert committees for EIA

- The Chairman will be an outstanding and **experienced ecologist or environmentalist or technical professional** with wide managerial experience in the relevant development.
- The representative of **Impact Assessment Agency** will act as a Member-Secretary.
- The membership of a committee **shall not exceed 15 members**.

The Committees will consist of experts in the following disciplines:

- Eco-system management
- Air/water pollution control
- Water resource management
- Flora/fauna conservation and management
- Land use planning, etc.

31.3.3. Benefits of EIA

- EIA **links environment with development** for **environmentally safe and sustainable development**.
- It enables the decision makers to analyse the effect of developmental activities on the environment well **before** the developmental project is implemented.
- It provides a cost-effective method to eliminate or minimize the adverse impact of developmental projects.
- EIA encourages the adaptation of **mitigation strategies** in the developmental plan.
- EIA makes sure that the developmental plan is environmentally sound and within limits of the **capacity of assimilation and regeneration of the ecosystem**.

31.3.4. Shortcomings of Environmental Impact Assessment

Applicability

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- There are several projects with significant environmental impacts that are exempted from the notification either because they are not listed in **schedule I**, or their **investments are less** than what is provided for in the notification.

Composition of expert committees and standards

- It is being found that the team formed for conducting EIA studies is lacking the expertise in various fields such as environmentalists, wildlife experts, anthropologists, and social scientists.

Public hearing

- Public comments are **not considered at the early stage**, which often leads to conflict at the later stage of project clearance.
- A number of projects with significant environmental and social impacts have been **excluded** from the **mandatory public hearing process**.
- The documents which the public are entitled to are seldom available on time.
- The data collectors do not pay respect to the indigenous knowledge of local people.

Quality of EIA

- One of the biggest concerns with the environmental clearance process is related to the **quality of EIA report** that are being carried out.
- The reports are generally incomplete and provided with false data.
- Many EIA reports are based on single season data.
- The EIA document in itself is so bulky and technical, which makes it very difficult to decipher so as to aid in the decision-making process.

Lack of Credibility

- It is the **responsibility of the project proponent** to commission the preparation of the EIA for its project.
- The EIA is actually funded by an agency or individual whose primary interest is to procure clearance for the project proposed.
- There is little chance that the final assessment presented is unbiased, even if the consultant may provide an unbiased assessment that is critical of the proposed project.
- There are so many cases of fraudulent EIA studies where erroneous data has been used, same facts used for two totally different places etc.
- There is no accreditation of EIA consultants, therefore any such consultant with a track record of fraudulent cases cannot be held liable for discrepancies.
- It is hard to imagine any consultant after being paid lakh of rupees, preparing a report for the project proponents, indicating that the project is not viable.

Case Study

- The MoEF constituted the **Western Ghats Experts Ecology Panel (WGEEP)** in 2010 under the Chairmanship of **Prof. Madhav Gadgil**.
- The Panel submitted its report in 2011 but it was not made public immediately due to its stringent assessment of the condition of Western Ghats.
- The report suggested many radical changes that needs to be brought to conserve Western Ghats.
- The recommendation if implemented would adversely affect mining mafia, sand mafia and local encroachers.
- Under pressure from various stakeholders, MoEF set up the **High Level Working Group (HLWG)**under the Chairmanship of **Dr. K. Kasturirangan** to study recommendations of WGEEP.

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- The HLWG had diluted many recommendations of WGEEP to satisfy the interests of various mafia.

Q. 'Gadgil Committee Report' and 'Kasturirangan Committee Report', sometimes seen in the news, are related to (2016)

a) constitutional reforms
b) Ganga Action Plan
c) linking of rivers
d) protection of Western Ghats

Answer: d)

31.3.5. Recommendations to improve EIA process

- Independent EIA Authority and sector wide EIAs are needed.
- **Transparency:** Dissemination of all information related to projects from notification to clearance to public.
- **Applicability:** All those projects where there is likely to be a significant alternation of ecosystems need to go through the process of environmental clearance, without exception.
- **Public hearing:** Public hearings should be applicable to all hitherto exempt categories of projects.
- **Quality:** All EIA reports should clearly state what are the adverse impacts that a proposed project will have. This should be a separate chapter and not hidden within technical details.
- **Avoid conflict of interest:** It is critical that the preparation of an EIA is completely independent of the project proponent.
- **Composition of expert committees:** The present executive committees should be replaced by expert's people from various stakeholder groups, who are reputed in environmental and other relevant fields.
- **Stringent punishments:** The EIA notification needs to build within it an automatic withdrawal of clearance if the conditions of clearance are being violated and introduce more stringent punishment for noncompliance. At present the EIA notification limits itself to the stage when environmental clearance is granted.

31.3.6. Salient Features of 2006 Amendment to EIA Notification

- Environment Impact Assessment Notification of 2006 has decentralized the environmental clearance projects by categorizing the developmental projects in two categories:
  1. **Category A (national level appraisal)** and
  2. **Category B (state level appraisal)**.
- **'Category A'** projects are appraised at **national level** by **Impact Assessment Agency (IAA)** and the **Expert Appraisal Committee (EAC)**.
- **Category B projects** are apprised at **state level**.
- State Level Environment Impact Assessment Authority (SEIAA) and State Level Expert Appraisal Committee (SEAC) are constituted to provide clearance to Category B process.
- After 2006 Amendment the EIA cycle comprises of **four stages**:
  1. **Screening**
  2. **Scoping**
  3. **Public hearing**
  4. **Appraisal**
- **Category A projects require mandatory environmental clearance** and thus **they do not undergo the screening process**.
- **Category B projects undergoes screening process**, and they are classified into two types.

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1. **Category B, projects (Mandatorily requires EIA)**.
2. **Category B2 projects (Do not require EIA/Environmental Clearance)**.

- Thus, **Category A projects and Category B**, projects **undergo the complete EIA process** whereas **Category B2 projects are excluded from complete EIA process**.

Amendment to EIA Notification 2006 in Respect of Bulk Drugs and Intermediates

- To ramp up production of various drugs during the COVID-19 crisis, MoEF, has made an amendment to EIA Notification 2006.
- According to the amendment, all projects or activities in respect of **bulk drugs and intermediates** have been **re-categorized** from the existing **Category 'A' to 'B2' category (Do not require EIA)**.
- Projects falling under **Category B2** are **exempted from** requirement of collection of **Base line data, EIA Studies** and **public consultation**.
- The re-categorization of such proposals has been done to facilitate **decentralization of appraisal to State Level** so as to fast track the process.

Amendment to EIA Notification 2006 for EC Waver for Oil and Gas Exploration

- Until now, all offshore and onshore oil and gas **exploration, development** and **production** projects fell user **'Category A'** treatment that require **prior EIA environmental clearance from the Centre**.
- MoEF has recently amended the EIA notification, 2006 to **exempt both onshore and offshore drilling explorations by oil & gas firms from EIA environmental clearance (EC)**.
- The new amendments demote exploratory projects to the **category of 'B2'**.
- This means the **authority is with the states** concerned and **will not require an EIA**.

Why now?

- GOI in 2019 relaxed rules to incentivise companies conducting oil exploration surveys in less-explored oil fields by allowing them to keep a greater share of revenue if they chance upon viable hydrocarbon blocks.
- This has led to a spurt in interest in oil and gas exploration.
- But the stringent EIA processes have turned into a roadblock.
- Moreover, the oil imports from the Persian Gulf region have become unreliable due to constant turmoil in the region.
- Also, the production of crude oil and natural gas in India has been going down.

Do the new amendments apply to development and production also?

- No, **developing a site as a hydrocarbon block will continue to merit a "category A" treatment**.

Criticism

- Exploration involves digging wells and conducting seismic surveys offshore which is ecologically intensive.
- Environmentalists aver that the recent amendments mean lax oversight.
- Offshore drilling operations can possibly affect fish, lead to a build-up of heavy water contaminants, disorient whales and sea life that rely on sonar for navigation and exacerbate the risk of oil spills.

31.3.7. EIA 2020 Notification Draft

- EIA 2020 Notification Draft is proposed by Union Government to amend the EIA Notification 2006.
- The draft notification defines three categories of projects namely **A, B1 & B2** founded on the social & economic impact & geographical extent of these impacts.
- The notification envisages two kinds of approval:
    1. **prior environment clearance (EC) with the approval of expert committees** &

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2. **environmental permission or provision (EP) without the approval of expert committees**.

- Almost **40 different projects** such as clay & sand extraction or digging well or foundations of buildings, solar thermal power plants & common effluent treatment plants are **exempted from prior EC or prior EP**.
- Several projects such as all **B2 projects**, irrigation, production of halogens, chemical fertilisers, acids manufacturing, biomedical waste treatment facilities, building construction & area development, elevated roads & flyovers, highways, or expressways **are exempted from public consultation**.

31.3.8. Issues with Draft EIA 2020

Ex Post Facto Clearance of Projects

- In 2017, MoEF passed a notification stating that any project functioning without EC can apply for environmental clearances.
- Now, this scheme is turned into a permanent move through the draft EIA, 2020.
- Primarily, all the industrial units & projects **operating illegally without environmental clearance** have an opportunity to turn into legal units under this provision by **submitting a remedial plan**.
- Any projects which may have grabbed land illegally or by coercion or by fraud & operate without environmental safeguards, too, have an option to benefit from the scheme.
- The Supreme Court, in a prior case passed an order stating that **post facto clearances are against the jurisprudence of environmental law** & it is detrimental to the environment.
- Post facto clearance was provided in India even before the issuance of these notifications.

Exclusion of Projects from Prior Environmental Clearance

- **40 projects** were **exempted** from getting **prior EC or environmental permission (EP)**.
- Sand deposits removal from agricultural field & community works are done away with prior EP or EC.
- According to the new draft construction of **buildings below 150000 square meters** (size of a small airport or stadium) do not require environmental clearance.
- Exempting such projects from the environment will have a deleterious effect on the environment.
- The **validity period of environmental clearance has been increased** for mining, river valley & other projects & this section does not sync with the object of the notification or the parent act.

Exclusion of Projects from Public Consultation

- Public participation is the cornerstone of EIA process.
- But several projects were exempted from public consultations.

Q. How does the draft Environment Impact Assessment (EIA) Notification, 2020 differ from the existing EIA Notification, 2006? (UPSC CSE Mains 2020 – 250 words).

31.4. Wild Life (Protection) Act of 1972 (WPA, 1972)

- In 1972, Parliament enacted the Wild Life Act (Protection) Act.
- Originally extended to whole of India except J&K but **after abrogation of Art 370, it covers J&K also**.
- **Wildlife wardens** and their staff administer the act.
- **State government** may appoint **Chief Wildlife Warden**. Central government may appoint directors & assistant directors.
- **Declaration of Sanctuary/NP:** State Government by Notification (no need to pass any law)
- **WPA provides for:**
  - ✓ **State wildlife advisory boards**

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- ✓ **Defines wildlife related terminologies** like habitat, hunting, zoo, sanctuary, NP, Reserve forest etc.
- ✓ Regulations for hunting wild animals and birds,
- ✓ Establishment of **sanctuaries & national parks**,
- ✓ **Regulations for trade in wild animals**, animal products & trophies, &
- ✓ **Management of Zoo's**
- ✓ Judicially imposed **penalties** for violating the Act.

- **Harming endangered species listed in Schedule I** of the Act is **prohibited throughout India**.
- **Hunting species**, like those requiring **special protection (Schedule II), big game (Schedule III), and small game (Schedule IV)**, is **regulated through licensing.**
- A few species classified as **vermin (Schedule V)**, may be **hunted without restrictions**.
- **Schedule VI** which provides **plant protections** was added by amendment of 1991.
- **No person is allowed to cultivate a specified plant mentioned in Schedule VI**, **except with a licence granted by the Chief Wildlife Warden**.
- **Schedule VI** of the Act lists **all 6 plants of Indian origin** included in **CITES appendices.**
  1) Beddomes' cycad
  2) Blue Vanda
  3) Kuth
  4) Ladies slipper orchids
  5) **Pitcher plant**
  6) Red Vanda
- WPA, 1972 is **against taxidermy** (preservation of dead wild animals as trophy or in the form of skins, antlers, horns, eggs, teeth or nails).

Q. In India, if a species of tortoise is declared protected under Schedule I of the Wildlife (Protection) Act, 1972, what does it imply? (2017)

a) It enjoys the same level of protection as the tiger.
b) It no longer exists in the wild, a few individuals are under captive protection; and now it is impossible to prevent its extinction.
c) It is endemic to a particular region of India.
d) Both (b) & (c) are correct in this context.

Explanation:

- Bengal Tiger's IUCN status is 'Endangered'. Gir Lions are also 'Endangered'. Hence, they fall under Schedule I of Wild-life (Protection) Act, 1972.

Answer: a) It enjoys the same level of protection as the tiger (Bengal Tiger's IUCN status is 'Endangered').

Q. According to the Wildlife (Protection) Act, 1972, which of the following animals cannot be hunted by any person except under some provisions provided by law? (2017)

1) Gharial
2) Indian wild ass
3) Wild buffalo

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 1 and 3 only

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d) 1, 2 and 3

Explanation:

- From the question, it is clear that the animal should fall under Schedule II or later.
- Gharial is 'Critically Endangered' and Water buffalo is 'Endangered'. Hence, they fall under Schedule I. (**Almost** every animal listed as CR or EN and some NT in IUCN Red List are in Schedule I).
- Indian wild ass is moved from Endangered (2015) to Near Threatened (2016). It is listed under Schedule I.

Answer: d) all

Q. If a particular plant species is placed under Schedule VI of The Wildlife Protection Act, 1972, what is the implication? (2020)

a) A licence is required to cultivate that plant.
b) Such a plant cannot be cultivated under any circumstances.
c) It is a Genetically Modified crop plant.
d) Such a plant is invasive and harmful to the ecosystem.

Answer: a) a license is required

31.4.2. Amendments

- The act has been **amended 7 times** so far 1982, 1986, 1991, 1993, 2002, 2006 & 2013.
- **WPA amendment 1982:**
  - ✓ Introduced a provision permitting the **capture and transportation** of wild animals for the **scientific management** of animal population.
- **WPA amendment 2002:**
  - ✓ It made punishment & penalty more stringent.
  - ✓ Provision for **National Board for Wildlife**.
- **WPA amendment 2006:**
  - ✓ **National Tiger Conservation Authority**
  - ✓ **Wildlife Crime Control Bureau**
- **WPA amendment 2013:**
  - ✓ Provision of imprisonment up to **7 years.**
  - ✓ **Protects hunting rights of Scheduled Tribes in Andaman & Nicobar Island.**

31.4.3. Delineation of Powers under the Act

- **No human activity is permitted** inside a **National Part except** for ones **permitted by Chief Wildlife Warden of State**.
- **Chief Wild Life Warden may permit hunting of any wild animal** if it has become dangerous to human life or is so disabled or diseased as to be beyond recovery.
- **Both State & Central Governments** can **notify National Parks & Wildlife Sanctuaries** under the act.
- **Central government** can declare an area as a Sanctuary or National Park where the state government ceases, or otherwise transfer any area within a sanctuary, to central government.
- **Alteration of boundaries** can be done by **State Government** only with **prior approval of National Board for Wildlife**.
- **Central government** may, by notification, declare any wild animal **other than those** specified in **Schedule I & II** to be **Vermin**.
  - ⇨ ***Vermin:*** *wild animals that are harmful to crops, animals, or which carry disease, e.g., rodents.*

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- **Central Government** may **add or delete any entry to or from any Schedule** or transfer any entry from one Part of a Schedule to another Part of the same Schedule or from one Schedule to another.

Monkeys Declared 'Vermin' in Himachal

- **MoEF** has recently declared **monkeys (Rhesus Macaque) as 'vermin'** in Himachal Pradesh.
- Local authorities can now **cull** this animal in certain identified non-forest areas in Shimla for one year.
- The decision was taken after the **state government reported** large-scale destruction of agriculture due to overpopulation of this species outside forests.
- Rhesus Macaques are protected species under **Schedule II of the Wildlife (Protection) Act, 1972**.
- Wildlife (Protection) Act, 1972 **allows for it to be hunted by declaring it** '**vermin**' for a specific period if it poses danger to human life or property.
- MoEF had earlier declared **wild pig as 'vermin'** in Uttarakhand.

31.4.4. Central Zoo Authority (CZA)

- **WPA, 1972** provided for constitution of **Central Zoo Authority by central government**.
- Authority shall consist of:
  - ✓ **Chairperson (Environment Minister)**
  - ✓ Such numbers of members **not exceeding 10 (appointed by central government)**
  - ✓ Member secretary
- **Functions:**
  - ✓ It can **recognise or derecognise any zoo in country**. No zoo shall be operated without being recognised by the Authority.
  - ✓ It lays down guidelines and prescribes rules under which animals may be **transferred/exchanged among zoos nationally and internationally.**
  - ✓ Provides technical & **financial assistance** to such zoos which have the potential to attain the desired standard in animal management.
  - ✓ It **identifies endangered species** of wild animals for purposes of **captive breeding** and assigning responsibility in this regard to a zoo.
- Standards and norms for housing, upkeep, health care and overall management of animals in zoos has been laid down under the **Recognition of Zoo Rules, 1992**.
- CZA is an **affiliate member** of the **World Association of Zoos and Aquariums (WAZA)**.
  - ✓ The World Association of Zoos and Aquariums (WAZA) is the **"umbrella" organization** for the world zoo and aquarium community.
  - ✓ Its mission is to provide leadership and support for zoos, aquariums, and partner organizations of the world in animal care, welfare & conservation.
  - ✓ Founded in **1935 at Basel, Switzerland**.

31.4.5. National Board for Wildlife (NBWL)

- NBWL is a **statutory body** constituted under **Wildlife (protection) Act 1972**.

History of National Board for Wildlife

- Due to the rapid decline in wildlife population, the GOI had constituted an advisory body designated as the **Indian Board for Wildlife (IBWL)** in 1952.
- The Indian Board for Wildlife was chaired by the **Prime Minister**.

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- As per the **Wildlife (Protection) Amendment Act, 2002**, a provision was incorporated for the constitution of the National Board for Wildlife, replacing the Indian Board for Wildlife.

Members of National Board for Wildlife

- The National Board for Wildlife has **47 members** with the **Prime Minister in the Chair**.
- The **Minister in charge of the MoEF** in GOI is the **Vice-Chairperson**.
- The Additional Director General of Forests (WL) & Director, Wildlife Preservation is the Member-Secretary.
- Other members include three Members of Parliament (two from Lok Sabha and one from Rajya Sabha), five NGOs and 10 eminent ecologists, conservationists, and environmentalists.

Duties and Powers

- The board is **advisory in nature** and advises the GOI in conservation and development of wildlife & forests.
- **It has power to review all wildlife-related matters** and **approve projects in and around national parks and sanctuaries**.
- **No alternation of boundaries in national parks and wildlife sanctuaries can be done without approval of the National Board for Wildlife**.

Standing Committee of NBWL

- The Standing Committee of NBWL considers proposals after a series of levels of scrutiny and have recommendations of the State Chief Wildlife Warden, State Government, and the **State Board for Wildlife**.
- The Committee recently approved the inclusion of **Caracal, a wild cat** found in some parts of **Rajasthan** and **Gujarat**, in the list of **critically endangered species (Indian CR List; not IUCN List)**.

31.4.6. Wildlife Advisory Board (State Board for Wildlife – SBWL)

- Wildlife Advisory Board is a **statuary body** of the **state (UT) government**.
- The **Wildlife (Protection) Act, 1972** mandates the **State (UT) Government** to constitute a Wildlife Advisory Board consisting of the following members:
  1. **Minister in charge of Forest** in the **State (UT)** is the **Chairman** (Chief Secretary will be the chairman if the minister's post is vacant);
  2. two members of the State (UT) Legislature;
  3. Secretary to the State (UT) Government;
  4. The Forest Officer in charge of the State Forest Department,
  5. an officer to be nominated by the Director;
  6. Chief Wildlife Warden;
  7. Officers of the State Forest Government not exceeding five
  8. such other person, not exceeding ten, who, in the opinion of the State Government, are interested in the protection of Wildlife, including the representatives of tribals not exceeding three.

Duties

- Advise the State Government in
  - ✓ **selection and administration of areas to be declared as Sanctuaries, National Parks, etc**;
  - ✓ formulation of the policy of protection and conservation of Wildlife and specified plants;
  - ✓ measures to be taken for harmonizing the needs of the tribals and other forest dwellers with the protection and conservation of wildlife; and
  - ✓ any matter that may be referred to it by the State Government.

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31.5. Indian Forest Act 1927 (IFA, 1927)

- The Indian Forest Act, 1927 was largely based on previous Indian Forest Acts implemented under the **British.** The most famous one was the Indian Forest Act of 1878.
- It provides legal framework for **protection & management** of forest & **duty leviable on Timber**.
- 1927 Act provides for procedure to be followed for declaring an area to be **Reserve/Protected/Village Forest**.
- **Degree of protection:** **Reserved forests > Protected forests > Village forests**
- **The Indian Forest (Amendment) Act, 2017:** It amended the definition of tree to **remove the word bamboos**. It means, **bamboo growing in non-forest areas** will be **waived off the requirement of permission for its felling or transportation for economic use**.

31.5.1. Reserve Forest

- **State government** may constitute **any forest land or waste land** as reserved forest which is the property of Government & **may sell the produce from these forests**.
- Before issuing official notification **state government** needs to appoint a **Forest Settlement Officer (has power of Civil Courts)** to **inquire & to provide settlements** to persons belonging to that area.
- **All activities are prohibited unless permitted in reserve forests.**

31.5.2. Protected Forest

- **Any land not included in Reserve Forest** is considered as **Protected Forest**.
- Protected forests are of 2 kinds:
  - ✓ **Demarcated protected forests**
  - ✓ **Undemarcated protected forests**
- In protected forests, **all activities are permitted unless it is prohibited**.

31.5.3. Village Forest

- **State government** can assign to any village community the rights of government (to or over) **any land which has been constituted as reserved forest**.
- State government may make rules for regulating the management of village forest, prescribing conditions under which the community may be provided with timber or other forest produce or pasture.

31.5.4. Criticism

- The act was solely confined to British Interests. It gave power to state to control the rights of tribal people.
- It never aimed to protect the forests of the country & just wanted to regulate forest produce & to levy taxes on timber & other forest produce which later became source of revenue for government.
- **MB Shah Report of 2010** & **Subramanian Report of 2015** talked about amending IFA, 1927.

31.5.5. Draft Indian Forest Act, 2019

- The draft IFA, 2019 aims at **re-establishing state power** over forests **at the cost of rights granted to the forest dwelling tribals** and other forest dwellers under the **Forest Rights Act of 2006**.
- Amendment has increased the focus to **conservation, enrichment, and sustainable management** of forest resources (this was missing in original 1927 Act).
- The amendment also introduces a **new category of forests — production forest** for production of timber, pulp, pulpwood, firewood, non-timber forest produce, medicinal plants etc.

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- **Forest Officials** will be able to **deny/diminish rights.**
  - ✓ It restricts tribals & forest dwellers' access to forest produce **even when they are recognised under the Forest Rights Act**
  - ✓ **It diminises the role of Gram Sabhas**
- Also, the powers to investigate, search and seize property, hold inquiries by forcing attendance of witnesses and evidence have been retained and in parts enhanced.
- Moreover, the **Centre will be able to intervene** in the states matters of management of forestlands. It can **overrule the states** on several counts when it deems fit.
- It empowers **forest bureaucracy** to **record forest rights** and gives it extraordinary power **to take away ("commute") individual and community rights** for declaring "reserve forest" by paying compensation.
- **Clause 26** provides that in case of fire in a reserved forest or theft of forest produce or grazing by cattle, all rights of pasture/forest-produce would be suspended.

31.6. Forest (Conservation) Act of 1980

- It was enacted to **consolidate the law related to forest, to control unchecked deforestation**, the **transit of forest produces** and the **duty liveable on timber and other forest produce**.
- **Forest officers** and their staff administer the Forest Act.
- Under the provisions of this Act, **prior approval of the Central Government** is required for **diversion of forestlands for non-forest purposes**.
- An **Advisory Committee** constituted under the Act **advises the Centre on these approvals**.
- The Act deals with the four categories of the forests, namely
  - ✓ **reserved forests,**
  - ✓ **village forests,**
  - ✓ **protected forests & private forests**.
- **1992 Amendment:** It provisioned for **allowing some non-forest activities in forests**, without cutting trees or limited cutting with prior approval of Central Govt.

31.6.1. Are Forests That Are Not Notified Protected Under Forest Act?

Yes, says the SC Order of 1996 (TN Godavarman Thirumulkpad vs the Union of India)

- In the order, the apex court had observed that the Forest (Conservation) Act, 1980, was brought in to prevent deforestation and goes on to add that its **nature of land classification doesn't matter**.
- The order read that "the provisions made for the conservation of forests **must apply to all forests irrespective of the nature of ownership or classification thereof**."
- Moreover, the court had also said that **forests will not just be areas recorded as forest land in government records**, but **all areas which are similar to the dictionary definition of a forest**.

The responsibility and powers of states

- Under the Godavarman order, the **states were supposed to identify and notify forests**.
- The **Forest Advisory Committee (FAC) of MoEF**, the **apex body that deliberates on granting permission to fell forests** said, "**criteria finalised by a state need not be subject to approval by MoEF**".

31.6.2. Development vs Conservation

- Sustainable development is hard to achieve because in most of the cases it may not be possible to complete development projects without harming the environment.

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- The scenario is grave in India as it doesn't have enough resources to balance both the environment and development.
- Projects have to be completed either with high environmental costs or high financial costs.
- With a complex web of legal processes (SC, NGT) and regulatory regimes (NTCA, National Board for Wildlife, etc), the development projects are stalled midway and the project costs skyrocket over the years.

Case studies

Case 1

- In June 2019, SC ordered to halt the construction of a road that passes through the "critical" corridor between the **Rajaji & Corbett Tiger Reserves** as it violates various provisions of the Forest Conservation Act.
- The road is being built **without the statutory approval** of the National Board for Wildlife.
- The advice of the **National Tiger Conservation Authority (NTCA)** has also not been taken.

Case 2

- **National Highway 44** from **Srinagar to Kanyakumari** is **India's longest highway**.
- Nine 'animal underpasses' were built in 2018 beneath a stretch of NH 44 between **Kanha** and **Pench tiger reserves** to prevent roadkill and reduce the '**barrier effect**' that roads have on the movement of animals.
- These underpasses are India's first examples of '**wildlife mitigation measures**' or attempts to remedy the impact of infrastructure on wild animals.
- The measures were undertaken after the Supreme Court ordered National Highways Authority of India (NHAI) to create mitigation measures in wildlife corridors.
- The nine underpasses are relatively small 'bridges,' and none of them have barriers against light and noise.

Q. Prelims practise: Statements:

1. NH 44 passes through Pench Tiger Reserve.
2. Kashmir-Kanyakumari highway passes through Pench Tiger Reserve.
3. Pench Tiger reserve is spread across the borders of Maharashtra and Madhya Pradesh.

Which of the above statement(s) are *false*?

a) 2 only
b) 2 and 3 only
c) 3 only
d) None

Explanation:

- All the statements are true.
- NH 44 (3700+ km) also known as Kashmir-Kanyakumari highway, is the longest highway in India.

Answer: D) None

31.7. Biodiversity Act 2000

- The legislation aims at regulating access to biological resources so as to ensure **equitable sharing** of benefits arising from their use.
- The Biological Diversity Bill was introduced in the Parliament in 2000 and was passed in 2002.

31.7.1. Salient features of the biodiversity legislation

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- The main intent of this legislation is to **protect India's rich biodiversity and associated knowledge against their use by foreign individuals and organizations** without sharing the benefits arising out of such use, and to check **biopiracy**.
- This bill seeks to **check biopiracy, protect biological diversity** and local growers through a three-tier structure of central and state boards and local committees.
- The Act provides for setting up of a **National Biodiversity Authority (NBA)**, **State Biodiversity Boards (SBBs)** and **Biodiversity Management Committees (BMCs)** in local bodies.
- The NBA will enjoy the power of a **civil court**. NBA and SBB are required to consult BMCs in decisions relating to use of biological resources. All **foreign nationals or organizations require prior approval of NBA** for obtaining biological resources and associated knowledge for any use.
- Indian individuals/entities require approval of NBA for **transferring results of research** with respect to any biological resources to **foreign nationals/organizations**.
- **Collaborative research projects and exchange of knowledge and resources are exempted** provided they are drawn as per the policy guidelines of the Central Government.
- However, Indian citizens/entities/local people including vaids and hakims have free access to use biological resources within the country for their own use, medicinal purposes and research purposes.
- While granting approvals, NBA will impose terms and conditions to secure **equitable sharing of benefits**.
- Before applying for any form of **IPRs (Intellectual Property Rights)** in or outside India for an invention based on research on a biological resource obtained from India, **prior approval of NBA will be required**.
- The monetary benefits, fees, royalties as a result of approvals by NBA will be deposited in **National Biodiversity Fund**.
- NBF will be used for conservation and development of areas from where resource has been accessed, in consultation with the local self-government concerned.
- There is provision for notifying **National Heritage Sites** important from standpoint of biodiversity by **State Governments in consultation with local self-government**.
- There also exists provision for notifying items, and areas for exemption provided such exclusion does not violate other provisions. This is to exempt normally traded commodities so as not to adversely affect trade.

Q. How does National Biodiversity Authority (NBA) help in protecting the Indian agriculture?

1) NBA checks the biopiracy and protects the indigenous and traditional genetic resources.
2) NBA directly monitors and supervises the scientific research on genetic modification of crop plants.
3) Application for intellectual Property Rights related to genetic / biological resources cannot be made without the approval of NBA.

Which of the statements given above is/are correct?

a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- The top **biotech regulator** in India for **Genetically Modified Organisms** is **Genetic Engineering Appraisal Committee (GEAC under functioning under the aegis of EPA, 1986)**.

Answer: c) 1 and 3 only

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32. National Environmental Legislation – Part II

32.1. Forest Rights Act, 2006 (FRA 2006)

- The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.
- Forest Rights Act, 2006 provides for the **restitution of deprived forest rights** across India.
- The Act is providing scope of **integrating conservation and livelihood rights of the people**.
- FRA is tool to
  - ✓ empower and strengthen the **local self-governance.**
  - ✓ address the livelihood security of the people.
  - ✓ address the issues of Conservation and management of the Natural Resources and conservation governance of India.
- For the first time Forest Rights Act recognizes and secures:
  - ✓ **Community Rights in addition to their Individual Rights**
  - ✓ Right to protect, regenerate or conserve or manage any community forest resource which the communities have been traditionally protecting and conserving for sustainable use.
  - ✓ **Right to intellectual property & traditional knowledge** related to biodiversity and cultural diversity.
  - ✓ Rights of displaced communities & rights over developmental activities

32.1.1. Salient Features

- Nodal Agency for the implementation is **Ministry of Tribal Affairs (MoTA)**.
- This Act is applicable for **Tribal and Other Traditional Forest Dwelling Communities**.
- The Act recognizes **the right of ownership** access to collect, use, and dispose of **minor forest produce by tribals**.
- **Section 2 of FRA: Defines Minor Forest Produce (MFP** — includes non-timber forest produce of plant origin).
- **National Parks and Sanctuaries have been included along with Reserve Forest, Protected Forests for the recognition of Rights**.
- FRA **only recognises pre-existing rights** which are already being exercised by eligible persons in NP & Sanctuaries. Also, it **secures tenure of existing forest dwellers,** but **no new rights are being created**.
- The **rights conferred** under the Act shall be **heritable but not alienable or transferable.**

The FRA act identifies 4 types of rights

1. **Title rights:** Gives right to ownership to land farmed forest dwellers subject to a **maximum of 4 hectares**.
2. **Use rights:** Rights of the dwellers extend to extracting Minor Forest Produce, grazing areas, etc.
3. **Relief and development rights:** Rehabilitation in case of illegal eviction or forced displacement and to basic amenities, subject to restrictions for forest protection.
4. **Forest management rights:** Right to protect, regenerate or conserve or manage any community forest resource which they have been traditionally protecting and conserving for sustainable use.

Criteria to claim rights under FRA

- **Criteria & evidence for Forest Dwelling Scheduled Tribes (FDST) to claim rights under FRA:**
  - ✓ Must be ST in an area.
  - ✓ Primarily resided in forest or land prior to December 2005
  - ✓ Depend on forest or forest land for livelihood needs
- **Criteria for other Traditional Forest Dweller (OFTD) to claim rights under FRA:**

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- ✓ Primarily resided in forest for 3 generation (75 years) prior to December 2005.
- ✓ Depend on forest for livelihood needs.

Note: If an OTFD village establishes its eligibility under the act, there is no need for every individual to establish its eligibility separately.

Gram Sabha

- As per the Act, the **Gram Sabha** has been designated as the competent authority for **initiating the process** of determining the **nature and extent of individual or community forest rights**.
- Term Gram Sabha & Village for purposes of FRA is defined in the act.

Can the decision of the Gram Sabha to reject or allow claim be appealed before court?

- Yes
  - ✓ **1st appeal:** Divisional Level Committee or Sub-Divisional Level Committee
  - ✓ **2nd appeal:** Before the courts

Q. Rehabilitation of human settlements is one of the important environmental impacts which always attracts controversy while planning major projects. Discuss the measures suggested for mitigation of this impact while proposing major developmental projects. (2016)

32.1.2. Critical Wildlife Habitats (CWH)

- The Critical Wildlife Habitats (CWH) have been envisaged in **Forest Rights Act, 2006**.
- CWH are defined under the act as the "**areas of national parks and sanctuaries** where it has been specifically and clearly established, case by case, on the basis of scientific and objective criteria, that such areas are **required to be kept as inviolate for the purposes of wildlife conservation**".
- **'Inviolate'** is a general term used to indicate **no human settlement and usage**.
- FRA identifies **MoEF as the agency to notify the guidelines** related to Critical Wildlife Habitats (CWH).

2011 Guidelines by MoEF

- **Gram Sabha's free informed consent must** be given before any relocation is carried out.
- Forest **rights are settled under the FRA** before a CWH can be declared in an area.
- An expert committee (members of the gram sabha, an ecologist, a tribal welfare NGO, a social scientist, Forest Department's officers) will take the main responsibility for determining the habitats.
- To notify a CWH, the Act requires state governments to establish that **the presence of right-holders is causing irreversible damage to wildlife and their habitats**.
- After more than a decade of FRA's existence, **not a single CWH had been notified**.

August 2018 Guidelines by MoEF

- In March 2017, the National Tiger Conservation Authority **(NTCA) issued an order to deny forest rights in critical tiger habitats (core areas of tiger reserves) in the absence of CWH guidelines**.
- MoEF finally issued CWH guidelines in January 2018 and NTCA order was superseded.
- However, unlike 2011, it sent the guidelines to states 'for action' without soliciting public comments.
- Activists see the guidelines as a dilution of FRA.

Key features of guidelines

- The **Chief Wildlife Warden** of a state will notify a **7 member expert committee,** chaired by a chief conservator of forest in-charge of a national park or sanctuary, for the purpose of identification of **CWH in a national park or sanctuary**.

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- The Expert Committee will identify areas within national parks and sanctuaries, based on scientific and objective criteria relevant to the protected area.
- The Expert Committee shall issue a **public notice 15 days in advance** on the intention to notify CWH.
- The public notice shall include details of areas required to be kept **inviolate**, criteria adopted for CWH identification, implication of the notification, and options of resettlement and rehabilitation schemes.
- The Expert Committee shall carry out open consultations with all stakeholders, and the proceedings and objections will be documented appropriately.
- The committee will submit the CWH proposal to the **Chief Wildlife Warden**.
- The final decision will be taken by the **Standing Committee of the National Board for Wildlife**.
- A MoTA representative would be invited during the deliberation of the proposal by the committee.
- **Following the committee's recommendation**, the notification of CWH will be published in the official gazette.

How do the guidelines dilute FRA?

- The guidelines have **replaced prior consent of the gram sabha** with a **public hearing** of all stakeholders.
- There is **no mechanism in the guidelines to address the objections** raised (by MoTA representative) during consultations.
- It is also not clear whether there would be single or multiple consultations for an entire Protected Area.
- In the existing guidelines, **CWH notification does not stand any public scrutiny** once 'open consultations' have been carried out (in contract the draft notification of every **Eco-sensitive Zones (ESZ) is put up in public domain for at least 60 days** before its finalisation).
- The guidelines are **silent on the issue of settlement of rights before notifying CWHs**.

Q. Consider the following statements: (2018)

1) The definition of "Critical Wildlife Habitat" is incorporated in the Forest Rights Act, 2006.
2) For the first time in India, Baigas have been given Habitat Rights.
3) Union Ministry of Environment, Forest and Climate Change officially decides and declares Habitat Rights for Primitive and Vulnerable Tribal Groups in any part of India.

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Explanation:

- 2016: **Baiga tribe (living in sal forests of Maikal Hills) in Madhya Pradesh** is the **first to get habitat rights in India** under the Forest Rights Act of 2006.
- Baiga community is one of the **75 particularly vulnerable tribal groups**, or PVTGs, who are eligible to get habitat rights under FRA.
- The definition of the **habitat rights** was incorporated **through an amendment in the FRA in 2012**.
- As per the amendment, the district level committee shall ensure that all PVTGs receive habitat rights, in consultation with these groups, after filing claims before the gram sabha.
- **It is MoTA that decides habitat rights**.

Answer: 1 and 2 only.

32.1.3. Community Forest Resources Guidelines

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- A study was commissioned by the **Ministry of Tribal Affairs (MoTA)** in 2019 to create state level guidelines for sustainable resource usage in **Community Forest Resource (CFR)**.
- In community forestry, **local community plays a significant role in forest management** and land use decision making by facilitating support of government as well as NGOs.
- It gained prominence in the mid-1970s and examples of community forestry can now be seen in many countries including Nepal, Indonesia, Korea, Brazil, India and North America.
- Community forest resource (CFR) rights are given under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA).

32.2. National Green Tribunal Act, 2010

- It is an act of the Parliament of India which enables creation of NGT to handle the **expeditious disposal of the cases pertaining to environmental issues**.
- It was enacted under India's constitutional provision of **Article 21**, which assures the citizens of India the **right to a healthy environment**.
- The specialized architecture of the NGT will facilitate **fast track resolution of environmental cases** and provide a boost to the implementation of many sustainable development measures.
- NGT is mandated to dispose the cases **within 6 months** of their respective appeals.
- Principal Bench of the NGT has been established in New Delhi, with regional benches in Pune (Western Zone Bench), Bhopal (Central Zone Bench), Chennai (Southern Bench) & Kolkata (Eastern Bench).

32.2.1. Members of NGT

- The **sanctioned strength** of the tribunal is **currently 10 expert members & 10 judicial members** although the **act allows for up to 20 of each**.
- The Chairman of the tribunal is required to be **a serving or retired Chief Justice of a High Court or a judge of the Supreme Court of India**.
- The **Chairman of the tribunal** also **serves as a judicial member**.
- Every bench of tribunal must consist of **at least 1 expert member & 1 judicial member**.

32.2.2. Jurisdiction

- The Tribunal has **Original Jurisdiction** on matters of "substantial question relating to environment" (i.e. a community at large is affected, damage to public health at broader level) & "damage to environment due to specific activity" (such as pollution).
- The term **"substantial"** is **not clearly defined** in the act.

32.2.3. Powers

- The Tribunal's **orders are binding,** and it has **power to grant relief in the form of compensation** & damages to affected persons.
- The NGT has the power to hear **all civil cases (not criminal)** relating to **environmental issues & questions** that are linked to the implementation of laws listed in **Schedule I of the NGT Act**.
- These include the following:
  1. The Water (Prevention & Control of Pollution) Act, 1974;
  2. The Water (Prevention & Control of Pollution) Cess Act, 1977;
  3. The Forest (Conservation) Act, 1980;

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4. The Air (Prevention & Control of Pollution) Act, 1981;
5. The Environment (Protection) Act, 1986;
6. **The Public Liability Insurance Act, 1991;**
7. The Biological Diversity Act, 2002.

- **Note: NGT has not been vested with powers to hear any matter relating to:**
  - ✓ **Wildlife (Protection) Act, 1972.**
  - ✓ **Indian Forest Act, 1927.**
  - ✓ **Various laws enacted by states relating to forests, tree preservation etc.**

32.2.4. Principles of Justice adopted by NGT

- **The NGT is not bound by the procedure laid down under the Code of Civil Procedure**, 1908, but shall be **guided by principles of natural justice**.
- Further, NGT is also **not bound by the rules of evidence** as enshrined in the Indian Evidence Act, 1872.
- It will be relatively easier (as opposed to approaching a court) for conservation groups to present facts & issues before the NGT, including pointing out technical flaws in a project, or proposing alternatives that could minimize environmental damage, but which have not been considered.
- **While passing Orders/decisions/awards, the NGT will apply the principles of**
  - ✓ **sustainable development,**
  - ✓ **the precautionary principle** &
  - ✓ **the polluter pays principles**.

Review & Appeal

- **Under Rule 22 of the NGT Rules,** The Tribunal **has powers to review its own decisions**.
- If this fails, an NGT Order **can be challenged before the Supreme Court within 90 days**.

32.2.5. Success of NGT

- Since its inception, the NGT has, apart from creating a new breed of legal practitioners, **protected vast acres of forest land**, halted polluting construction activities in metros & smaller towns.
- It has **penalised errant officials** who have turned a blind eye towards enforcing the laws & held large corporate entities to account.
- It has **protected the rights of tribal communities** & ensured the enforcement of the "polluter pays" principle in letter & spirit.
- In this endeavour it has been assisted by brilliant practitioners, many of whom are young counsels, passionate & dedicated towards protecting the environment.
- Perhaps the biggest testament to the NGT's success has been the attitude of the ruling government towards it.

32.2.6. Challenges faced by NGT

- Issue of '**tribunalisation**' i.e., government appointing the members & issue of conflict of interest because of the cases are of government.
- Similar to what has been done with the Right to Information Act, the Central Government attempts to **dilute the criteria for appointments** to the NGT & other tribunals.
- **Other challenges:**
  - ✓ NGT must focus less on governance issues & more on adjudication.
  - ✓ Benches have to expand manifold.

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✓ Vacancies have to be filled quick redressal of issues.

Q. The National Green Tribunal Act, 2010 was enacted in consonance with which of the following provisions of the Constitution of India?

1) Right to healthy environment, construed as a part of part of Right to life under Article 21.
2) Provision of grants for raising the level of administration in the Scheduled Areas for the welfare of Scheduled Tribes under Article 275(1)

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: a)

Q. How is the National Green Tribunal (NGT) different from the Central Pollution Control Board (CPCB) (2018)

1) The NGT has been established by an Act whereas the CPCB has been created by an executive order of the Government.
2) The NGT provides environmental justice and helps reduce the burden of litigation in the higher courts whereas the CPCB promotes cleanliness of streams and wells and aims to improve the quality of air in the country.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Explanation:

- **CPCB is a statutory organisation under the MoEF**.
- It was established under the **Water (Prevention and Control of Pollution) Act, 1974**.

Answer: b) 2 only

32.3. Coastal Regulation Zone (CRZ) Rules

- The coastal stretches of seas, bays, estuaries, creeks, rivers and back waters which are **influenced by tidal action** are declared **"Coastal Regulation Zone" (CRZ)** in 1991.
- In the 1991 rules, the regulation zone has been defined as the **area up to 500 m from the high-tide line**.
- **National Coastal Zone Management Authority (NCZMA)** and **State Coastal Zone Management Authority (SCZMA)** are created for enforcement and monitoring of the CRZ Notification.
- Implementation is to be done by **state governments** through their **SCZMA**. The states need to frame their **own coastal zone management plans** in accordance with the central Rules.
- These authorities have been delegated powers under **Section 5 of the Environmental (Protection) Act, 1986** to take various measures for protecting and improving the quality of the coastal environment.
- **CRZ Rules** are made by the **Union Environment Ministry**.

32.3.1. Coastal Regulation Zone (CRZ) Rules 2011

- Despite several amendments, states found the 1991 CRZ Rules to be extremely restrictive.

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- The 1991 Rules also created hurdles for industrial and infrastructure projects such Navi Mumbai.
- The Centre notified fresh **CRZ Rules in 2011**, which addressed some concerns.
- An exemption was made for the **construction of the Navi Mumbai airport**.
- Projects of the **Department of Atomic Energy** (nuclear power plants near the coast) were exempted.

CRZ-I

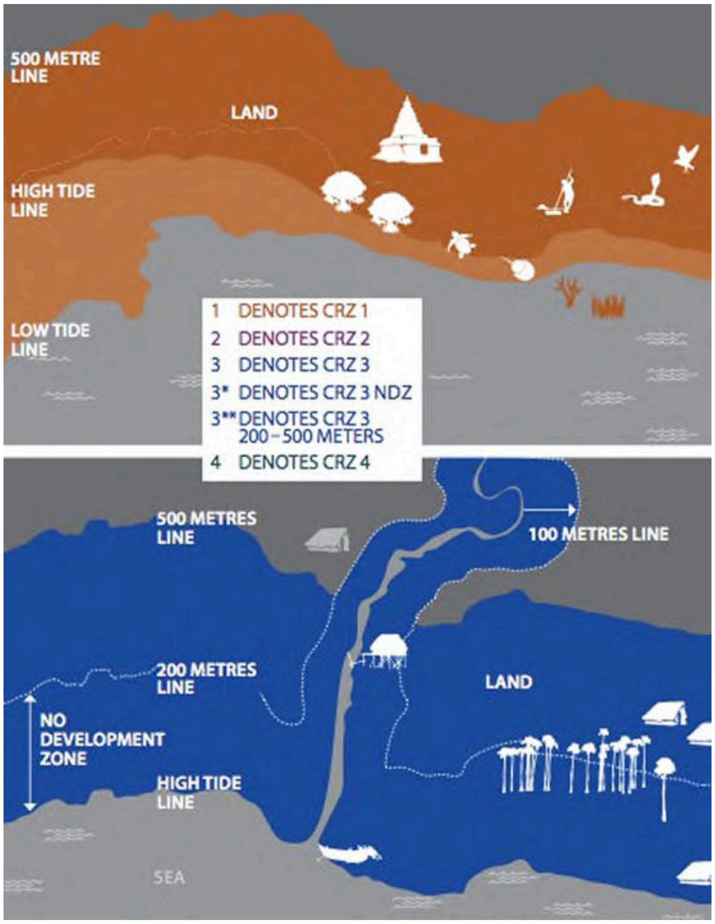
- **Ecological sensitive area and the area between High Tide Line (HTL) and Low Tide Line (LTL)**.
- **No new construction is permitted** except for a few specified most essential activities like support activities for Atomic Energy Plants and Defense requirements, facilities required for disposal of treated effluents and other port related waterfront activities.

CRZ-II

- The area that has been **developed up to or close to the shore line** which includes the designated urban areas that are substantially built up.
- **Buildings permitted only on the landward side** of the existing authorized structures.

CRZ-III

- The areas that are relatively undisturbed and those which do not belong to either CRZ-I or CRZ-II which includes mainly the **rural area** and those not substantially built up within designated urban areas.
- The area up **to 200 meters from HTL is earmarked as "No Development Zone"**.
- **No construction is permitted within this zone** except for repairs to the existing authorized structures.
- **Development of vacant plots between 200 and 500 meters of HTL is permitted in CRZ III** for the purpose of construction of dwelling units and hotels/beach resorts subject to certain conditions.



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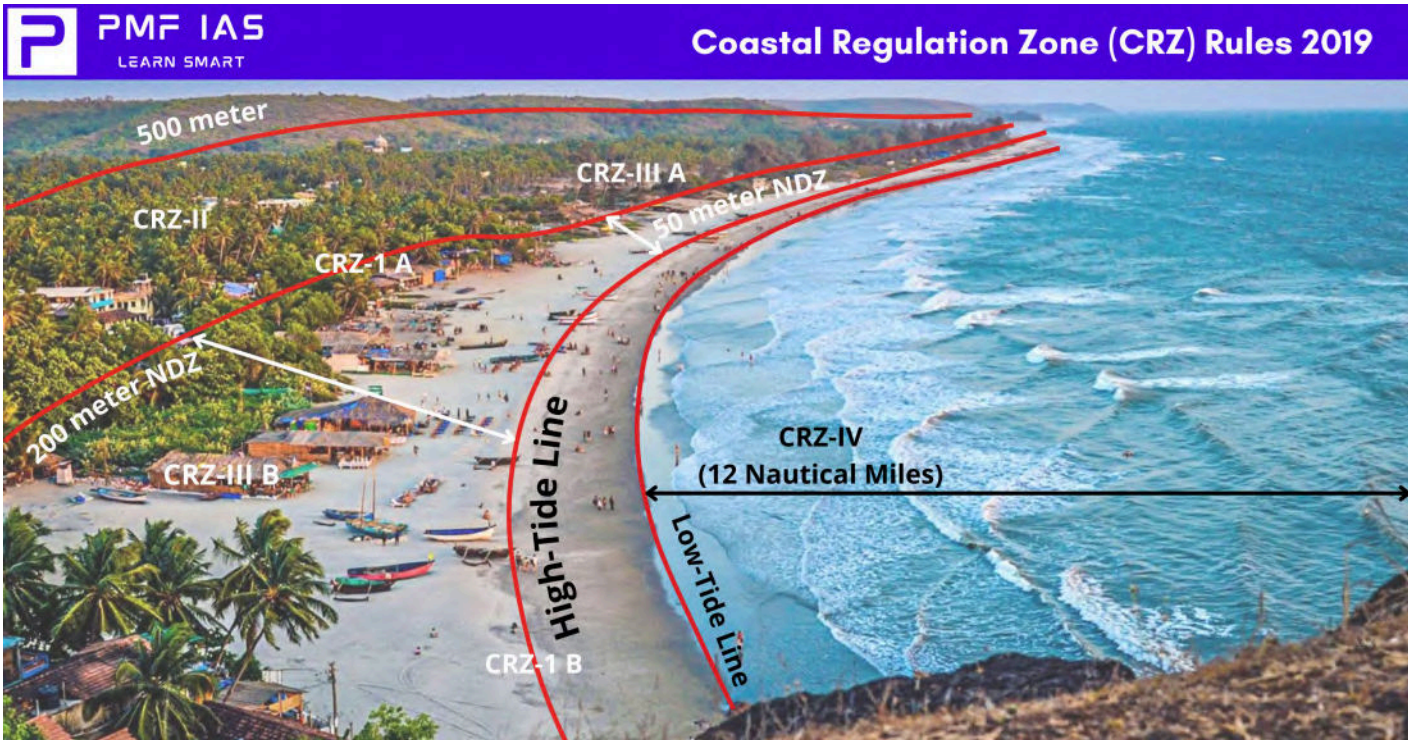
CRZ-IV

- The activities impugning on the sea and tidal influenced water bodies will be regulated except for traditional fishing and related activities undertaken by local communities.
- No untreated sewage, effluents, pollution from oil drilling shall be let off or dumped.

32.3.2. CRZ Rules 2019

- In January 2019, the government notified new CRZ Rules with the stated objectives of **promoting sustainable development (encourage tourism in coastal areas)** and conserving coastal environments.
- For the so-called **CRZ-III (Rural) areas**, **two separate categories** have been stipulated.
  1. **CRZ-IIIA**: In the **densely populated rural areas (CRZ-IIIA)** with a population density of 2,161 per sq km as per the 2011 Census, the **no-development zone is now 50 m from the high-tide level, as against the 200 m stipulated earlier**.
  2. **CRZ-IIIB**: In the **CRZ-IIIB** category (rural areas with population density below 2,161 per sq km) continue to have a **no-development zone extending up to 200 m from the high-tide line**.
- The new Rules have a **no-development zone of 20 m for all islands close to the mainland coast**, and **for all backwater islands in the mainland**.
- **Floor Space Index Norms eased**: In the CRZ 2019 Notification, the government decided to **de-freeze the Floor Space Index** and permit FSI for construction projects.
- **Tourism infrastructure permitted in coastal areas**: The new norms permit **temporary tourism facilities** such as shacks, toilet blocks, change rooms, drinking water facilities, etc. in Beaches.
- **Streamlining of CRZ Clearances**: Projects which are located in the **CRZ-I (Ecologically Sensitive Areas)** and **CRZ IV (area covered between Low Tide Line and 12 Nautical Miles seaward)** will be dealt with for CRZ clearance by the **Union Ministry of Environment**.
- The powers for clearances with respect to **CRZ-II and III have been delegated at the State level**.



32.3.3. Draft Integrated Coastal Zone Management

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- **MoEF** has unveiled a draft plan that will dictate how prospective infrastructure projects situated along the coast ought to be assessed before they can apply for clearance.
- The draft **Environmental & Social Management Framework** is part of a **World Bank-funded** project.
- The draft plan was prepared by the Society for Integrated Coastal Management, a **MoEF-affiliated body**.
- The document lays out guidelines for coastal States to adopt when they approve projects in coastal zones.
- So far, Gujarat, Odisha and WB, have prepared ICZM Plans with support from the World Bank.
- The key activities proposed for coastal zone development include:
  - ✓ mangrove afforestation/shelter beds,
  - ✓ habitat conservation activities such as restoration of sea-grass meadows,
  - ✓ eco-restoration of sacred groves,
  - ✓ development of hatcheries,
  - ✓ rearing/rescue centres for turtles and other marine animals,
  - ✓ creation of infrastructure for tourism,
  - ✓ restoration and recharge of water bodies,
  - ✓ beach cleaning and development, and
  - ✓ other small infrastructure facilities.
- Livelihood improvement projects include:
  - ✓ demonstration of climate resilient or salinity resistant agriculture,
  - ✓ water harvesting and recharge/storage,
  - ✓ creation of infrastructure and facilities to support eco-tourism,
  - ✓ community-based small-scale mariculture,
  - ✓ seaweed cultivation,
  - ✓ aquaponics, and
  - ✓ value addition to other livelihood activities.
- The plan describes how "environmental and social aspects" ought to be integrated into the planning, design, implementation of projects.

Why is there a need for ICZM?

- Inadequate planning has often obstructed coastal zone development projects.
- In June, the Bombay HC struck down the Coastal Regulation Zone (CRZ) clearance for ₹14,000-crore Coastal Road to be constructed between South Mumbai and Western suburbs.
- This was on the grounds of an inadequate scientific study by the Maharashtra CRZ and lapses by the MoEF.

32.3.4. Activities Permitted in the CRZ of Certain Beaches

- Environment Ministry has relaxed Coastal Regulation Zone (CRZ) **rules** that restrict construction near beaches to help States construct infrastructure & **enable them to receive 'Blue Flag' certification**.
- The following activities & facilities **would be permitted in the CRZ of the beaches, including islands,** subject to maintaining a **minimum distance of 10 meters from the High Tide Line (HTL)**:
  - ✓ Portable toilet blocks, change rooms & shower panels.
  - ✓ Grey water treatment plant.
  - ✓ Solid waste management plant.
  - ✓ Purified drinking water facility.
  - ✓ Other associated facilities or infrastructure, as per requirements of Blue Flag Certification.

Blue Flag Beaches

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- 'Blue Flag' certification is an **eco-label certification** that can be obtained by a **beach, marina, or sustainable boating tourism operator**.
- '**Blue Flag' certification** is **awarded annually** by the **Denmark-based** non-profit **Foundation for Environmental Education**.
- It was **started in France in 1985** & in areas out of Europe in 2001.
- The programme promotes sustainable development in freshwater & marine areas through **4 main criteria:**
  1. **Water quality**
  2. **Environmental management**
  3. **Environmental education**
  4. **Safety**
- Beaches are selected based on **33 stringent parameters** by an eminent international **jury comprising members of the**:
  - ✓ **United Nations Environment Programme (UNEP)**
  - ✓ **United Nations World Tourism Organization (UNWTO)**
  - ✓ **Foundation for Environmental Education (FEE)**
  - ✓ **International Union for Conservation of Nature (IUCN)**

Blue Flag Beaches in India

13 pilot beaches have been identified by MoEF for the certification

1. **Ghoghla Beach (Diu)**
2. **Shivrajpur beach (Gujarat)**
3. **Bhogave (Maharashtra),**
4. **Padubidri (Karnataka)**
5. **Kasarkod (Karnataka),**
6. **Kappad beach (Kerala),**
7. **Kovalam beach (Tamil Nadu),**
8. **Eden beach (Puducherry),**
9. **Rushikonda beach (Andhra Pradesh),**
10. **Miramar beach (Goa),**
11. **Golden beach (Odisha),**
12. **Radhanagar beach (Andaman & Nicobar Islands) and**
13. **Bangaram beach (Lakshadweep).**

8 Indian Beachesgot the certification in October 2020

1. **Shivrajpur (Dwarka-Gujarat)**
2. **Ghoghla (Diu)**
3. **Kasarkod [NOT Kasargod which is in Kerala]**
4. **Padubidri (Karnataka)**
5. **Kappad (Kerala)**
6. **Rushikonda (AP)**
7. **Golden Beach (Odisha)**
8. **Radhanagar (A&N Islands)**

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BEAMS (Beach Environment & Aesthetics Management Services)

- **Society for Integrated Coastal Management (Under Environment Ministry)** undertakes program **"BEAMS" (Beach Environment & Aesthetics Management Services)** under its **ICZM (Integrated Coastal Zone Management) project**.
- **It aims to:**
  - ✓ Abate pollution in coastal waters.
  - ✓ Promote sustainable development of beach facilities.
  - ✓ Protect & conserve coastal ecosystems & natural resources.
  - ✓ Promotes local authorities & stakeholders to maintain high standards of cleanliness, hygiene & safety.
  - ✓ Promotes beach recreation in absolute harmony with nature.

Society of Integrated Coastal Management (SICOM)

- It is established **under the aegis of the Ministry of Environment.**
- It aims for vibrant, healthy & resilient Coastal & Marine Environment.
- It is the **nodal agency** for successful implementation of **Integrated Coastal Zone Management (ICZM) practices** & **ENCORE project** in all the 13 Coastal States/UTs.
- It acts as **secretariat** to the **National Coastal Zone Management Authority (NCZMA)**.

Integrated Coastal Zone Management (ICZM)

- Its objective is to assist the government in building national capacity for implementation of comprehensive coastal management approach in the country &piloting the integrated coastal zone management in three states: Gujarat, communities Orissa & West Bengal.

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- It focuses on protecting life & property of vulnerable coastal.

Enhancing Coastal & Ocean Resource Efficiency Program (ENCORE)

- It aims to strengthen integrated coastal zone management in India.
- It enhances coastal resource efficiency & resilience & implements integrated coastal management approaches.

32.3.5. Issues with the way the CRZ rules are executed

- State government and local bodies often overlooked rules to facilitate construction in CRZ areas.
- CZMAs are often limited by existing laws. **CMZAs cannot take action but can only file cases**.
- The **delegation of power** goes to principal secretary or additional chief secretary of environment, chairman or member secretary of pollution control board and district collector.

Maradu Apartments Demolition Order

- In 2007, the Maradu panchayat (now a municipality) issued a show-cause notice to builders that constructed high rise structures on the banks of **Vembanad Lake**, citing violations of CRZ norms.
- The Local Self Government directed the local body (Maradu panchayat) to revoke the permits.
- However, the **panchayat only issued a show-cause notice** to the builders for violating CRZ rules.
- The builders got a stay order from the **Kerala HC** in 2007 which **allowed them to continue construction**.
- The Kerala HC ruled that the **builders could not be taken to task** (since they had permits) for not referring the applications to **Kerala CZMA** for a 'No-Objection Certificate' — a mandatory clearance.
- KCZMA filed a petition in the SC against the Kerala HC's order.
- **As per the CRZ notification of 1991 the area in question came under CRZ-III**.
- Maradu became a municipality in 2010 and consequently, the **2011 CRZ notification categorised it under CRZ-II**, though the MoEFCC approved this only in February 2019.
- **SC ordered the demolition** of the apartments as they fell within **CRZ-III** at the time of construction.
- The buildings were finally razed in January 21 by the Kerala government.
- The case raises multiple concerns regarding environmental governance and adjudication.

Implications

Ecological Implications

- Contamination of the lake due to the debris.
- Air pollution caused by the demolition posed severe health hazards to those residing nearby.

Economic Implications: Builders, Buyers and the state, all lost money

- Explosion of illegal structures could cause collateral damage to the neighbouring structures.
- The economical vulnerable poor and the middle class are usually the primary victims of such demolitions.

Moral implications: Who is at fault? Who paid the price?

Municipal Authorities

- When there is weak enforcement of laws, corruption, and undue influences, violations become common.
- The civic authorities of Maradu turned a blind eye to the reminders from the KCZMA.
- It was the **responsibility of the municipality and not the project proponents to send the files for clearance**.

Builders

- The builders had constructed the apartments after conspiring with panchayat officials in 2006.
- In the Maradu case, the builders had never applied for a CRZ clearance.

Buyers

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- Purchased the flats knowing similar constructions were challenged in courts elsewhere.
- In a populous bourgeoning country like India, people are eternally land-hungry, and owning a house is an ultimate dream for many. To realise their dream, people ignorantly violate laws.

Judiciary

- Kerala HC held that permit holders should not be made liable and allowed the construction.
- SC relied on **bureaucratic categorisation** and ignored that the **construction was based on permission granted by the local government** and ordered the demolition of the structures.
- While State authorities and courts were complicit in allowing the buildings to be constructed in the first place, liability was ultimately placed squarely on the apartment owners.

Legal: Ambiguity surrounding the CRZ rules

- **SC ordered the demolition** of the apartments as they fell within **CRZ-III** at the time of construction.
- As per the latest CRZ rules, new buildings can be constructed at the same site as the area falls under **CRZ-II** !

Mains Practise

Q. "Demolishing illegal structures comes with a baggage of moral, constitutional (legal), ecological and humanitarian implications." Examine this statement with relevant examples.

Q. "**Environmental governance** is a victim of pathologies of the executive and the judicial decision-making on environment and urban development in India." Examine.

Q. "For **environmental justice**, India needs a strong **environmental governance** system that enables all stakeholders to prevent violations instead of the court becoming India's new demolition man." Elaborate this statement citing recent examples.

32.3.6. What activities are permitted in the CRZ of certain beaches?

- Environment Ministry has relaxed Coastal Regulation Zone (CRZ) **rules** that restrict construction near beaches to help States construct infrastructure & **enable them to receive 'Blue Flag' certification**.
- The following activities & facilities **would be permitted in the CRZ of the beaches, including islands,** subject to maintaining a **minimum distance of 10 meters from the High Tide Line (HTL)**:
  - ✓ Portable toilet blocks, change rooms & shower panels.
  - ✓ Grey water treatment plant.
  - ✓ Solid waste management plant.
  - ✓ Purified drinking water facility.
  - ✓ Other associated facilities or infrastructure, as per requirements of Blue Flag Certification.

32.4. Laws to Protect Against Chemical Disasters in India

- At the time of the Bhopal gas tragedy, the Indian Penal Code (IPC) was the only relevant law.
- In the wake of the Bhopal tragedy, GOI enacted the **Environment Act of 1986**.
- **Bhopal Gas Leak (Processing of Claims) Act, 1985:** It gives powers to the central government to secure the claims arising out of or connected with the Bhopal gas tragedy.
- **The Environment Protection Act, 1986:** It gives **powers to the central government** to undertake measures for improving the environment and set standards and inspect industrial units.
- **The Public Liability Insurance Act, 1991:** It is an insurance meant to provide relief to persons affected by accidents that occur while handling hazardous substances.

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Major Industrial Gas Leak Disasters in India

	When?	Where?	Cause?	Casualties
Bhopal Gas Tragedy	December 2-3, 1984	Union Carbide India, Pesticide Plant, Bhopal, MP	Methyl isocyanate (MIC) Gas Leak	Nearly 5000 were Killed and more than 5,00,000 were affected
GAIL Pipeline Blast	June 27, 2014	GAIL Plant, Nagaram, East Godavari, A.P.	Underground Natural gas Pipeline Rupture	Over 18 People were Killed and Over 40 People were Injured
Bhilai Steel Plant Gas Leak	June 12, 2014	Bhilai Steel Plant, Durg, C.G.	Methane Gas Leak	6 People were Killed and over 40 people were injured
Tughlaqabad Gas Leak	May 6, 2017	Container Depot. Tughlaqabad, E-E delhi	Chemical gas Leakage from a Container Truck	Over 400 School Children were Hospitalised
Kanpur Ammonia Gas Leak	May 15, 2017	A Cold Storage Facility at Shivrajpur, Kanpur, U.P.	Ammonia gas Leak	5 People were Killed and 9 were injured.
Belur Chlorine Gas Leak	May 16, 2017	A Water Treatment plant at Gandehalli, Belur, Karnataka	Chlorine gas Leak	More than 10 people fell Sick.
Bhilai Steel Plant Blast	Oct 9, 2018	Bhilai Steel Plant, Durg, C.G.	Explosion in a Gas Pipeline Connected to the Coke Oven	9 People were Killed and 14 were Injured

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What happened in Vishakapattanam?

What Leaked?	What Is It??	How Dangerous Is it?	What is it used for?
Styrene	It is also called ethenylbenzene, vinylbenzene and phenylbenzene. It is an organic compound derieved from benzene	Sustained exposure affects the central nervous system. Studies have shown that it causes cancer.	Manufacturing polystyrene, plastics, fibreglass, rubber and latex.

- **The National Environment Appellate Authority Act, 1997:** Under this Act, the National Environment Appellate Authority can hear appeals regarding the restriction of areas in which any industries, operations or processes or class of industries shall not be carried out or shall be carried out subject to certain safeguards under the **Environment (Protection) Act, 1986**.
- **National Green Tribunal, 2010:** It provided for the establishment of the National Green Tribunal for effective and expeditious disposal of causes related to environmental protection and conservation of forests.

32.4.1. State of Chemical Disaster Risk in India

- According to the National Disaster Management Authority (NDMA), in the recent past, over 130 significant chemical accidents have been reported in the country.
- Further, there are thousands of registered hazardous factories and unorganised sectors dealing with numerous ranges of hazardous material posing serious and complex levels of disaster risks.
- There are over **1861 Major Accident Hazard (MAH) units** spread across 301 districts and 25 states and three Union Territories in all zones of the country.
- The Major Accident is defined as an incident involving loss of life or ten or more injuries. Further it also involves the release of toxic chemical or explosion.

32.4.2. Strict vs Absolute Liability Principle

- The most recent accidental **Styrene gas** leak in a plant run by LG in Visakhapatnam in Andhra Pradesh has killed several people and caused respiratory illness in many.
- NGT found LG Polymers prima facie liable under the **strict liability principle** for the Vizag gas leak.
- However, according to the lawyers, the term absolute liability principle should have been used instead.
- **Strict Liability Principle: a party is not liable and need not pay compensation if a hazardous substance escapes its premises by accident or by an 'act of God'** among other circumstances.

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- **Absolute Liability Principle: a party in a hazardous industry cannot claim any exemption. It has to mandatorily pay compensation**, whether or not the disaster was caused by its negligence.
- The **National Green Tribunal Act of 2010** incorporates the **absolute liability principle**.
- **NGT act mandates that the absolute liability should be applied even if the disaster caused is an accident**.

The Supreme Court's Intervention

- The Supreme Court, in the M.C. Mehta vs Union of India 1987, found **strict liability principle inadequate** to protect citizens' rights and **replaced it with the absolute liability principle**.
- This judgement came on the **Oleum gas (fuming sulfuric acid) leak case** of Delhi in 1986.
- The court found that strict liability provided companies with several exemptions from assuming liability.
- Absolute liability, on the other hand, provides no exemptions and is **part of Article 21 (Right to Life)**.
- Considering the 1984 Bhopal gas tragedy, SC wanted corporations to be made fully liable.

32.5. Pesticide Regulatory Regime in India

- India currently has a registered list of **295 pesticides & 746 approved formulations**.
- These pesticides are registered by the **Registration Committee (RC)**.
- The **Central Insecticides Board (CIB)** acts as an **advisory body**.
- The two regulatory bodies are governed by the **Insecticides Act, 1968** & the **Insecticides Rules, 1971**.
- The Act & Rules intend to "regulate the import, manufacture, sale, transport, distribution & use of insecticides with a view to prevent risk to human beings or animals".
- Since its inception, the **CIBRC (as they are together called) registers pesticides** upon receiving applications along with efficacy, toxicity, & safety data from the company.
- The **Ministry of Agriculture has the authority to cancel registrations** & allow continued use or in some cases even ban the pesticides **upon the recommendation of the RC**.

32.5.1. Pesticides Management Bill 2020

- Union Cabinet has approved the Pesticide Management Bill 2020.
- The bill aims to promote the use of **organic alternatives** to chemical pesticides in the country.
- The bill will empower farmers to get all the information in a **digital format** regarding pesticides, including their strengths and weaknesses and the risk and alternatives involved.
- The bill will also include the provision of **compensating the farmers** in case of losses due to the use of **spurious or low quality of pesticides**.
- Any person who wants to import, manufacture, or export pesticides would have to **register under the new bill** and **provide all details** regarding any claims, efficacy, safety, and infrastructure to stock that pesticide.
- The information will also include **details on the pesticide's potential effects on the environment**.
- The bill also plans to **regulate pesticides-related advertisements** to **check misleading claims** by industries and manufacturers.

Need for a fresh law

- At present, pesticides are regulated through the **Insecticides Act, 1968** & **Insecticides Rules, 1971**.
- The 1968 Act is ineffective in taking cognizance of scientific evidence on the ill effects of pesticides.
- Besides, there is a dire need to address the **pesticide poisoning deaths** and hospitalisations of farmers.
- Wildlife and livestock are also poisoned routinely by toxic pesticides.

Pesticide usage in India

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- India is the fourth-largest producer of pesticides in the world.
- The recent increase in pesticide use is because of higher use of herbicides like **glyphosate** (**many countries have banned it)** as cost of manual weed control has risen due to increase in agricultural wages.
- It is reported that eight states consume more than 70% of the pesticides used in India.
- Total pesticide consumption is the highest in **Maharashtra**, followed by **UP, Punjab** & **Haryana**.
- Amongst the crops, **paddy accounts for the maximum share (26-28%)**, followed by **cotton (18-20%)**.

Recommendations

States must be empowered to ban certain pesticides

- Inadequate representation and powers to the state governments is a serious concern.
- There have been several instances, where states (like Punjab, Kerala etc.) wanted to ban a particular herbicide like **glyphosate** in their respective states but were not allowed to do so for a long time.

Pesticide promotion must not be allowed

- Just like pharmaceutical drugs, pesticides due to their hazardous nature, must not be allowed to be promoted.
- All kinds of advertisements of pesticides must be banned in India.
- Interaction of pesticide company/dealer with farmers must not be allowed and considered illegal.

Class I pesticides should be banned

- Based on acute toxicity, WHO classifies certain pesticides as **extremely hazardous (Class Ia)** and **highly hazardous (Class Ib)**.
- Necessary provisions should be made in the bill to ban sale and use of Class I pesticides.
- In August 2018, the Ministry of Agriculture banned 18 Class I pesticides.
- But it left out two heavily used Class I pesticides: **Monocrotophos** and **Carbofuran**.

Personal protective gear

- The bill must incorporate a provision which makes it illegal to sell a pesticide without personal protective equipment or safety gear.

Polluter Pays

- The Polluter Pays' principle should be the basis for fixing liability and compensation from the company.
- Any pesticide registration must follow a transparent assessment procedure.

Give powers to Union Ministry of Health

- Further, legislative powers to regulate pesticides should be transferred to the Union Ministry of Health and Family Welfare from the MoAFW, to address the health-related concerns without any conflict of interest.

32.5.2. There is a near total collapse of pesticide regulation mechanism in India

2020 Notification on Draft ban order

- In May 2020, a notification consisting of a draft ban order was released by **the Ministry of Agriculture & Farmers' Welfare**, **proposing a ban on the manufacture, sales, & imports of 27 pesticides in India**.
- Several are **WHO Class I pesticides** (**'extremely hazardous' & 'highly hazardous')**, some are classified as probable **human carcinogens**, some documented for their toxicity on bees, fish, earthworms, etc.
- Several are implicated in fatal pesticide poisonings whether it is occupational, or accidental.
- 24 of the 27 pesticides are banned in other countries.
- Many of these have been part of 2015 **Anupam Verma Committee** reviewed 66 "bannable" pesticides.

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- At the behest of the industry, the **Department of Chemicals & Petrochemicals** cited Covid-19 pandemic situation as an excuse in proceeding with the draft ban order.

Notable pesticides in the list of 27 proposed-to-be-banned pesticides

- ✓ **Carcinogenic: Oxyflourfen, Pendimethalin (causes Thyroid follicular cell adenoma)**
- ✓ **Endocrine disruption: Dicofol, Carbofuran, Oxyflourfen**
- ✓ **Eco-toxic: Carbofuran, Monocrotophos, Carbofuran, Oxyflourfen**

Q. In India, the use of carbofuran, methyl parathion phorate and triazophos is viewed with apprehension. These chemicals are used as

a) pesticides in agriculture
b) preservatives in processed foods
c) fruit-ripening agents
d) moisturising agents in cosmetics

Answer: a)

Deemed to be Registered Pesticides or DRPs

- DRPs are pesticides that **were in use before the Insecticides Act of 1968** & could be used on the assumption that they would be registration once the mandatory data on efficacy & toxicity is generated.
- There are at least 51 such DRPs.
- Six of these have been withdrawn, eight have been banned & five are to be phased out by the end of 2020.
- The list of DRPs is not readily available on any government website (lack of transparency).
- Importantly, **17 of the 27 proposed-to-be-banned pesticides are DRPs**.
- These biosafety (safety to human health & environment) of these DRPs was never assessed.
- Bio-safety data submitted & review committee reports are shrouded in secrecy.
- They have been turned down even under RTI.
- They all are being considered registered, irrespective of the data submitted.
- No other nation is known to be following such an arbitrary, risky, & unscientific regulatory practice.
- Many of the DRPs have been banned in various countries, even decades ago.

32.6. India's National Action Plan on Climate Change (NAPCC)

- NAPCC was published in **2008** by the then-Prime Minister's Council on Climate Change.
- The National Action Plan hinges on the **development and use of new technologies**.
- The implementation of the plan includes **public private partnerships and civil society action**.
- The focus will be on **promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation**.
- There are **Eight National Missions** which form the core of the National Action Plan.

1) **National Solar Mission (started in 2010 to promote the use of solar power)**
2) **National Mission for Enhanced Energy Efficiency (approved in 2009)**
3) **National Mission on Sustainable Habitat (approved in 2011)**
4) **National Water Mission**
5) **National Mission for Sustaining the Himalayan Ecosystem (approved in 2014)**
6) **National Mission for A Green India (approved in 2014)**
7) **National Mission for Sustainable Agriculture (approved in 2010)**
8) **National Mission on Strategic Knowledge for Climate Change (NMSKCC)**

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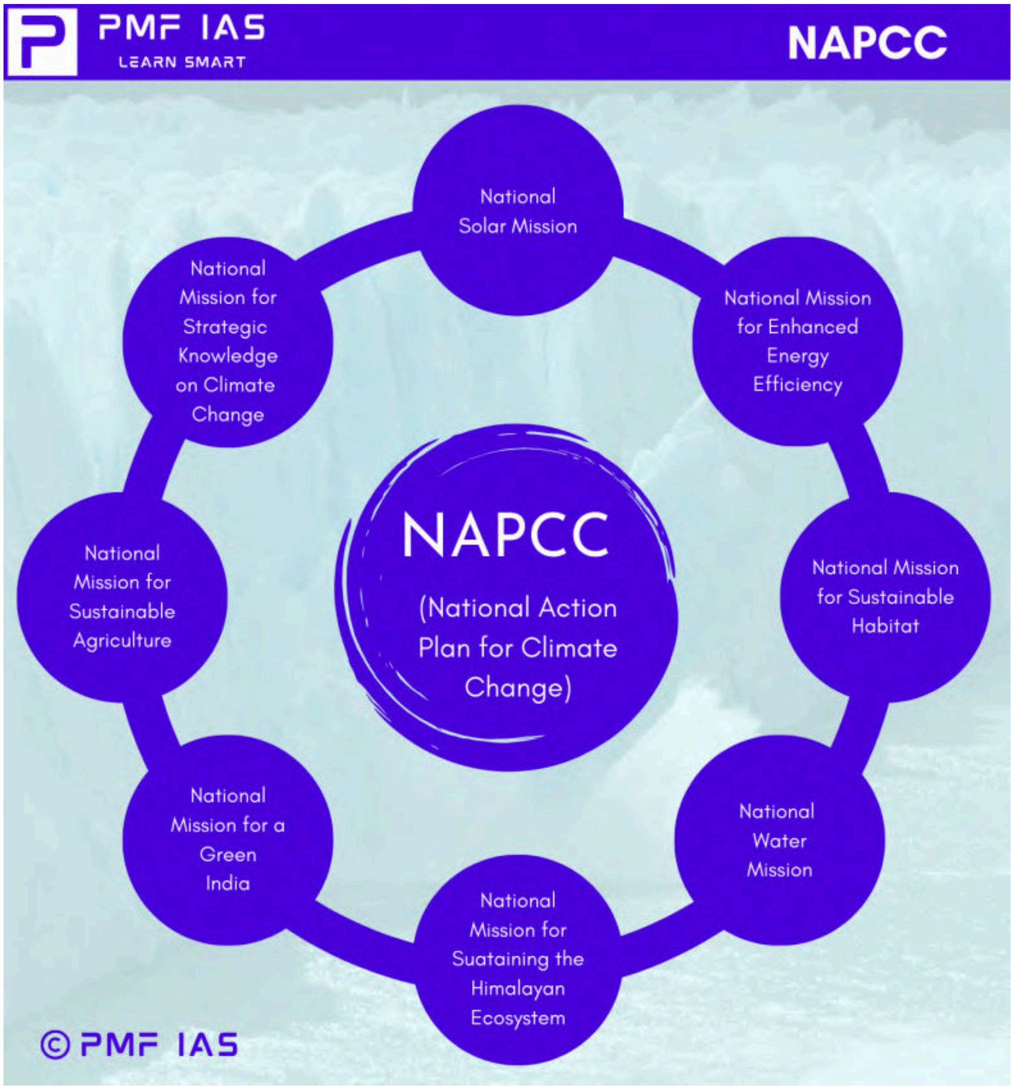
9) **National Bio-Energy Mission (approved in 2017 but not yet legally included under NAPCC)**



32.6.1. National Solar Mission (JNNSM)

- Also known as the **Jawaharlal Nehru National Solar Mission (JNNSM)**.
- Objectives:
  1. To establish India as a **global leader in solar energy**, by creating the policy conditions for its diffusion across the country as quickly as possible.
  2. To promote ecologically sustainable growth while addressing India's energy security challenges.
- It is one of the several initiatives that are part of **National Action Plan on Climate Change**.
- The program was inaugurated in 2010.
- Initial target was 20GW by 2022 and it was increased to **100 GW** in 2015 Union budget.
- Long term goal: Global leader in solar energy; maximum in energy production.
- Immediate goal: Setting up an enabling environment for solar technology penetration in the country.

Targets are set for three phases

1. **First phase 2010-13**
2. **Second phase 2013–17**
3. **Third Phase 2017–22**

- At each stage progress will be reviewed and roadmap for future targets will be adopted.

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- Total target of **100,000 MW (100 GW) by 2022**.
- MNRE has proposed to achieve it through
  1. **40 GW through Rooftop Solar Projects** and
  2. **60 GW through Large and Medium Scale solar projects**.

Q. 'Net metering' is sometimes seen in the news in the context of promoting the (2016)

a) production and use of solar energy by the households/consumers
b) use of piped natural gas in the kitchens of households
c) installation of CNG kits in motor-cars
d) installation of water meters in urban households

Explanation: Net Metering

- Net Metering is a billing mechanism for grid connected Home Rooftop Solar Installation where
  - ✓ The electricity generated by the solar panels is fed into the utility grid
  - ✓ Household draws electricity from the utility grid
- The household **pays only for the difference** between the energy units it consumes from the grid and the energy units fed into the grid. This is measured by a bi-directional meter called Net Meter.

Answer: a)

Domestic content controversy

Q. To what factors can the recent dramatic fall in equipment costs and tariff of solar energy be attributed? What implications does the trend have for the thermal power producers and the related industry? (2015)

- Guidelines for the solar mission **mandated cells and modules for solar PV projects based on crystalline silicon to be manufactured in India**. This accounts to **over 60% of total system costs**.
- For **solar thermal**, guidelines mandated **30% project to have domestic content**.
- Cpnflicts emerged between power project developers and solar PV equipment manufacturers.
- The former camp prefers to source modules by **accessing highly competitive global market** to attain flexible pricing, better quality, predictable delivery and use of latest technologies.
- The latter camp prefers a controlled/planned environment to force developers to purchase modules from a small, albeit growing, group of module manufacturers in India.
- **US Trade Representative** has filed a complaint at World Trade Organization challenging India's domestic content requirements citing discrimination against US exports.
- **WTO ruled in favor of USA**.

Types of PV Modules

- **Crystalline Silicon (Semiconductor) PV Module**
  - ✓ Costly
  - ✓ High Conversion Efficiency
- **Amorphous Silicon (Semiconductor)PV Module**
  - ✓ Suitable for low-cost product.
  - ✓ Low Conversion Efficiency

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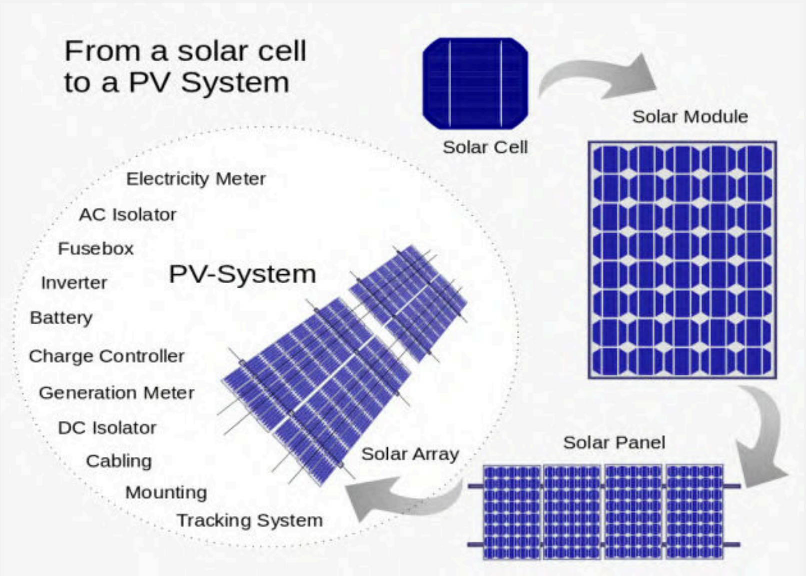

32.6.2. National Mission for Enhanced Energy Efficiency (NMEEE)

- Objective: Promote the market for energy efficiency by fostering innovative policies and effective market instruments.
- The mission document, which was approved in 2010, established the immense energy efficiency potential of India, which was about Rs. 74,000 crores.
- A recent World Bank study has estimated the country's energy efficiency market to be at 1.6 lakh crores.

NMEEE includes 4 efficiency initiatives under its umbrella:

1) Perform Achieve and Trade (PAT)

Assigning energy reduction targets to large energy intensive industries and distributing Energy Saving Certificates (ESCerts) on achievement of the targets. These ESCerts can then be traded.

- Consumers who are not able to meet their energy savings targets will buy the **ESCerts**.

2) Market Transformation for Energy Efficiency (MTEE)

Promoting adoption of energy efficient equipment and appliances through innovative business models.

Programs that were developed under this scheme include:

- **Domestic Efficient Lighting Program: Unnat Jeevan by Affordable LEDs for All (UJALA)** program to promote the use of LED lighting for households.
- **Super-Efficient Equipment Program (SEEP):** Under this program, the manufacturers are incentivized by GOI to elevate the efficiency standards of the equipment.
- **Bureau of Energy Efficiency (BEE – Ministry of Power)** launched the program in the XII five-year plan with a focus on ceiling fans, considering its wide use and impact on domestic energy consumption.

3) Energy Efficiency Financing Platform (EEFP)

Increasing the confidence of financial institutions and investors to support energy efficiency initiatives.

- The EEFP initiative is intended towards catalysing the **finances for energy efficiency sector** by addressing the barriers and challenges in market development and project implementation.
- It provides a platform for financial institutions, investors and project developers to increase their confidence in supporting energy conservation and efficiency projects.

4) Framework for Energy Efficiency Economic Development (FEEED)

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Promoting energy efficiency initiatives by hedging against investment risks.

- BEE institutionalized two types of funds in order to protect the confidence of banks and investors in energy efficiency projects and to avoid the stalling of projects due to lack of funds.
    1. **Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE):** The fund guarantees a risk cover for banks and investors for up to 50% loan amount or INR 10 crore per project, whichever is less.
    2. **Venture Capital Fund for Energy Efficiency (VCFEE):** This fund is intended towards promoting equity financing (stock, share) in the energy efficiency sector and thus reducing the impact of non-availability of debt financing (bond, loan) to small size companies and projects. The equity support is equivalent to INR 2 crore or 15% of total equity whichever is less.

Energy Conservation Act 2001

- Act provides for the **legal framework, institutional arrangement & regulatory mechanism** at the **Central and State level** to embark upon energy efficiency drive in the country.
- **5 major provisions of EC Act relate to:**
    1) Designated Consumers
    2) **Standard and Labelling of Appliances**
    3) **Energy Conservation Building Codes**
    4) **Creation of Bureau of Energy Efficiency**
    5) Establishment of **Energy Conservation Fund**
- **ECA Amendment Act 2010:** It empowered Central Government to issue the **energy savings certificate to the designated consumer** whose energy consumption is less than the prescribed norms.

Bureau of Energy Efficiency

- The Bureau of Energy Efficiency is a **statuary agency** under the **Ministry of Power**.
- It was created in March 2002 under the provisions of the nation's **2001 Energy Conservation Act**.
- BEE's function is to develop programs which will increase the conservation and efficient use of energy.
- It **mandatory for certain appliances in India to have BEE ratings**.

Q. On which of the following can you find the BEE Star Label? (2016)

a) Ceiling fans
b) Electric geysers
c) Tubular fluorescent lamps

Select the correct answer using the code given below.

a) 1 and 2 only
b) 3 only
c) 2 and 3 only
d) 1, 2 and 3

Answer: d) all

Energy Conservation Building Code (ECBC)

- It was launched by **Ministry of Power** in 2007.
- It sets minimum energy standards for **commercial buildings** connected load of 100kW or contract demand of 120 KVA and above.

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- Implementation of code is in **voluntary in nature**.

ECO Niwas Samhita 2018

- **Ministry of Power** has launched the ECO Niwas Samhita 2018.
- It is also known as **Energy Conservation Building Code for Residential Buildings (ECBCR).**
- Eco Niwas Samhita aims to benefit the occupants & the environment by **promoting energy efficiency** in design and construction of homes, apartments & townships.

Stars & Labelling Programme (BEE Star Label)

- **Bureau of Energy Efficiency** initiated the Standards & Labelling programme for equipment and appliances in **2006.**
- It aims to provide the consumer an **informed choice about the energy saving** and thereby the cost saving potential of the relevant marketed product.
- Scheme is invoked for 23 equipment/appliances including **10 for which it is mandatory**.

Mandatory Appliances as of March 2019

1. **Room Air Conditioners**
2. **Frost Free Refrigerators**
3. **Tubular Florescent Lamp**
4. **Distribution Transformer**
5. **Room Air Conditioner (Casettes, Floor Standing Tower, Ceiling, Corner AC)**
6. **Direct Cool Refrigerator**
7. **Color TV**
8. **Electric Geysers**
9. **Inverter Air conditioners**
10. **LED Lamps**

Source

Voluntary Appliances as of March 2019

1. Induction Motors
2. Agricultural Pump Sets
3. Ceiling Fans
4. Domestic Liquefied Petroleum Gas(LPG) Stoves
5. Washing Machine
6. Computer (Notebook /Laptops)
7. Ballast (Electronic/Magnetic)
8. Office equipment's (Printer, Copier, Scanner, MFD's).
9. Diesel Engine Driven Monoset Pumps for Agricultural Purposes
10. Soli State Inverter
11. Diesel Generator
12. Chillers
13. Microwave Ovens

Chiller Star Labelling Program

- It was launched by **Ministry of Power**.
- It has been formulated by **Bureau of Energy Efficiency (BEE)**.

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- It encourages the deployment of **Energy Efficient Chiller Systems** in the country by providing star rating in terms of its energy performance.
- This initiative will promote advancement technology for central **HVAC (Heating, ventilation, and air conditioning) systems** and will also facilitate **energy efficient solutions** for the large commercial and industrial applications.

What are Chillers?

- Chillers are used extensively for space conditioning of buildings and for industrial process **cooling applications**.
- Chillers are energy intensive system contributes more than 40% of the total energy consumption in commercial buildings.

UJALA & SLNP

- **Unnat Jyoti by Affordable LEDs for All (UJALA)** & **LED Street Lighting National Programme (SLNP)** GOI's zero subsidy programmes.
- SLNP is the world's largest streetlight replacement programme.
- UJALA is the world's largest domestic lighting project.
- Both have been implemented by **Energy Efficiency Services Limited (EESL)**, a **joint venture of PSUs under the Ministry of Power**.
- Under the SLNP programme, over 1.03 crore smart LED streetlights have been installed till date.
- This enabled an estimated greenhouse gas (GHG) emission reduction of 4.80 million tCO_2 annually.
- Through the UJALA initiative, over 36.13 crore LED bulbs have been distributed across India.
- This has resulted in an estimated GHG emission reduction of 38 million tCO2 annually.
- Apart from this, the Government of India initiated the **Gram Swaraj Abhiyan (GSA)** in 2018, which was aimed at apprising rural communities of various government welfare schemes and initiatives.

New Energy Performance Standards for ACs

- **Bureau of Energy Efficiency (BEE)** has notified new energy standards for Room Air Conditioners.
- The **24 °C default setting** has been made mandatory from Jan 1, 2020 for all room air conditioners (RACs) covered under the ambit of BEE star-labelling program.
- Some countries like Japan have put in place regulation to keep the default AC temperature at 28 °C.
- Additionally, the **Indian Seasonal Energy Efficiency Ratio (ISEER)** as per the new standards will be applicable from 1st January 2021 onwards.

Benefits of "24 °C default setting" for ACs

- As per BEE, the total connected load in India due to air conditioning will be 200 GW by 2030.
- Normal human body temperature is approximately 36-37°C, commercial establishments, hotels and offices maintain temperature around 18-21°C. This is not only uncomfortable but is actually unhealthy.
- Every 1 degree increase in the AC temperature setting results in saving of **6 per cent of electricity consumed**.
- The 24 °C default setting will result in savings of 20 billion units of electricity in one year alone.

Indian Seasonal Energy Efficiency Ratio (ISEER)

- The star rating system is a labelling system, under which the manufacturer is required to place a label indicating how much electricity the appliance is likely to consume under pre-set conditions.
- Previously, star rating of ACs in India worked using the **Energy Efficiency Ratio (EER)**.
- EER is the ratio of **cooling capacity to power input**.
- Air conditioners with higher EER are preferred, as these are more efficient.

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- In many countries, the **Seasonal Energy Efficiency Ratio** is used for calculating the energy efficiency of the air conditioner as there is season-wise variation in temperature.
- Taking this into consideration, BEE has defined **Indian Seasonal Energy Efficiency Ratio (ISEER)** for **ACs as a star rating method for India** from January 2018.
- ISEER is the ratio of Cooling Seasonal Total Load (CSTL) to Cooling Seasonal Energy Consumption (CSEC).

Sustainable Energy for All (SE4All)

- It is a **multi-stake holder partnership** between governments, private sector & civil society.
- It is launched by **UN Secretary General in 2011**.
- It supports progress on **Sustainable Development Goal 7** & **Paris Agreement** by meeting 3 interlinked objectives to be **achieved by 2030:**
  - ✓ **Double the global rate of improvement in energy efficiency.**
  - ✓ **Double the share of renewable energy in global energy mix.**
  - ✓ **Universal access to modern energy services.**

32.6.3. National Mission on Sustainable Habitat

- The National Mission on Sustainable Habitat was approved in 2010.
- It seeks to promote:
  - ✓ **Improvements in energy efficiency in buildings** by extending **energy conservation building code** to new and large commercial buildings.
  - ✓ Better urban planning and efficient and convenient public transport to facilitate the growth of **medium and small cities**.
  - ✓ Improved management of solid and liquid waste, e.g., recycling of material and urban waste management (like producing power from waste).
  - ✓ Improved ability of habitats to adapt to climate change and measures for improving advance warning systems for extreme weather events.
  - ✓ Conservation through appropriate changes in legal and regulatory framework.

The Mission is being implemented through the following programmes of **Ministry of Urban Development**:

1) **Atal Mission on Rejuvenation and Urban Transformation (AMRUT)**
2) **Swachh Bharat Mission**
3) **Smart Cities Mission**
4) **Urban Transport Programme**

32.6.4. National Water Mission (NWM) Mission

- Objective is to ensure **integrated water resource management** helping to conserve water, minimize wastage and ensure **more equitable distribution** both across and within states.
- The Mission, in line with National Water Policy, aims to
  - ✓ increase water use efficiency by 20%.
  - ✓ ensure that a considerable share of the water needs of urban areas are met through recycling.
  - ✓ ensure that the water requirements of coastal cities are met through modern desalination technologies.
  - ✓ ensure basin level management strategies by working with states to deal with variability in rainfall.
- The Mission aims to achieve its objectives through:
  - ✓ Increasing efficiency through regulatory mechanisms (differential entitlements and pricing).
  - ✓ Enhanced storage both above and below ground, rainwater harvesting.

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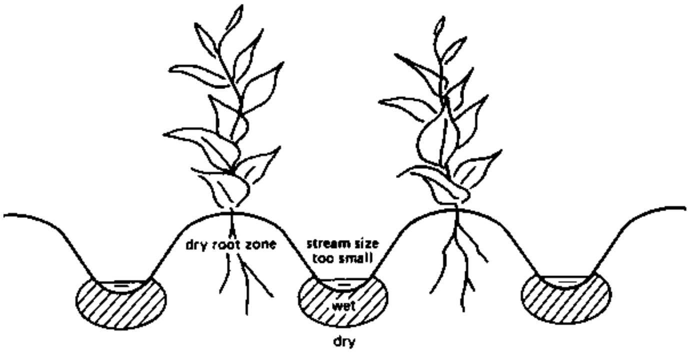
- ✓ Incentivising water-neutral or water-positive technologies, and adoption of large scale irrigation programmes which rely on sprinklers, drip irrigation and **ridge and furrow irrigation**.
- ⇨ *Ridge ad furrow irrigation: The crops are grown on the ridges and the furrows are used to irrigate.*



32.6.5. National Mission for Sustaining the Himalayan Ecosystem (NMSHE)

- The primary objective of the Mission is to
  - ✓ develop a sustainable model to continuously assess the health status of the Himalayan Ecosystem, and
  - ✓ enable policy bodies in their policy-formulation as also to assist States in the Indian Himalayan Region with implementation of actions selected for sustainable development.
- The NMSHE will attempt to address a variety of important issues:
  - ✓ Himalayan glaciers and associated hydrological consequences.
  - ✓ Prediction and management of natural hazards.
  - ✓ Biodiversity conservation and protection.
  - ✓ Wild life conservation and protection.
  - ✓ **Traditional knowledge** societies and their livelihood.
- The effect of Climate Change on Himalayan glaciers and associated hydrological consequences:
  - ✓ Increased drought like situations due to overall decrease in the number of rainy days.
  - ✓ Increased flood events due to overall increase in the rainy day intensity.
  - ✓ Effect on groundwater quality in alluvial aquifers due to increased flood and drought events.
  - ✓ Influence on groundwater recharge due to changes in precipitation and evaporation.
  - ✓ Increased saline intrusion of coastal and island aquifers due to rising sea levels.

32.6.6. National Mission for A Green India (Green India Mission)

- The **Green India Mission** aims to **sequester 2.523 billion tonnes of carbon by 2020-30**, and this involves adding **30 million hectares** in addition to existing forest.
- It aims at
  - ✓ protecting; restoring and **enhancing India's diminishing forest cover** and
  - ✓ responding to climate change by a combination of adaptation and mitigation measures.
  - ✓ Enhanced annual CO_2 sequestration by 50 to 60 million tons in the year 2020.
- The mission will be implemented on both **public as well as private lands**.
- The mission will local communities in planning, decision making, implementation and monitoring.

The intended major outcomes of the project

- Improved ecosystem services and reversal of land degradation.
- Augmentation of the shared natural resources on which extreme poor communities depend.

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- Enhance connectivity between Protected Areas (PA) through biological corridors.
- Inclusive growth by reaching the communities living around remote forest areas.
- Increased wage labour opportunities during the lean agriculture season.
- Improvement in quality of forest cover and ecosystem services of forests, degraded grassland and wetlands.
- Eco-restoration of shifting cultivation areas, cold deserts, mangroves, ravines and abandoned mining areas.
- Improvement in forest and tree cover in urban/peri-urban lands.
- Improvement in tree cover on agricultural lands and other non-forest lands (agroforestry/social forestry).

National Mission on Seabuckthorn

- The initiative is a part of **Sub-Mission on Cold Desert Ecosystems under the Green India Mission**.
- Seabuckthorn, popularly known as **Leh berries** is also called the **"Wonder plant" and "Ladakh gold"**.
- The MoEF and DRDO have launched the initiative for Seabuckthorn cultivation in the cold deserts.
- It has multi-purpose medicinal and nutritional properties.
- The plant has the ability to fix atmospheric nitrogen.
- It is **tolerant to extreme temperatures** and has an extensive root system, making it **ideal for controlling soil erosion and preventing desertification**.

Q. Which of the following best describes/describe the aim of 'Green India Mission' of the Government of India?

1) Incorporating environmental benefits and costs into the Union and State Budgets thereby implementing the `green accounting'
2) Launching the second green revolution to enhance agricultural output so as to ensure food security to one and all in the future
3) Restoring and enhancing forest cover and responding to climate change by a combination of adaptation and mitigation measures

Select the correct answer using the code given below.

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Answer: c) 3 only

Q. Government of India encourages the cultivation of 'sea buckthorn'. What is the importance of this plant?

1) It helps in controlling soil erosion and in preventing desertification.
2) It is a rich source of biodiesel.
3) It has nutritional value and is well-adapted to live in cold areas of high altitudes.
4) Its timber is of great commercial value.

Which of the statements given above is /are correct?

a) 2, 3 and 4 only
b) 1 and 3 only
c) 1, 2, 3 and 4
d) 1 only

Answer: b) 1 and 3 only

32.6.7. National Mission for Sustainable Agriculture (NMSA)

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- NMSA has been formulated for enhancing agricultural productivity especially in **rainfed areas**.
- **60% of the country's net sown area is rainfed** and accounts for **40% of the total food production**.
- The focus areas are integrated farming, water use efficiency, soil health and resource conservation.
- Stated dimensions of NMSA:
  1. Improved crop seeds, livestock and fish cultures
  2. Water Use Efficiency
  3. Pest Management
  4. Improved Farm Practices
  5. Nutrient Management
  6. Agricultural insurance
  7. Credit support
  8. Markets
  9. Access to Information
  10. Livelihood diversification

Soil Health Management (SHM)

- **Soil Health Management (SHM)** is one of the components under **NMSA**.
- SHM aims at
  - ✓ promoting **Integrated Nutrient Management (INM)** through **judicious use of chemical fertilizers** including secondary and micronutrients in conjunction with organic manures and bio fertilizers and
  - ✓ fertilizer testing facilities to improve **soil test based recommendations** to farmers.

Soil Health Card (SHC) Scheme

- SHC scheme is under implementation since 2015 to provide Soil Health Card to all farmers **every two years**.
- SHC will provide information to farmers on **soil nutrients status** of their soil and **recommendation on appropriate dosage of nutrients to be applied** for improving soil health and its fertility.
- For setting up of soil health laboratories under the scheme, the states have been sanctioned hundreds of static and mobile labs.
- Under the scheme village farmers up to 40 years of age are eligible to set up **soil health laboratories**.
- A laboratory costs up to Rs 5 lakhs, 75% of which can be funded by the central and state governments.
- A study conducted by the National Productivity Council (NPC) says **the application of Soil Health Card recommendations has led to a decline of 8-10% in use of chemical fertilizers**.

What Soil Health Card contains?

- It will contain the status of his soil with respect to 12 parameters, namely
  - ✓ N-P-K (Macro-nutrients);
  - ✓ Sulphur (Secondary- nutrient);
  - ✓ Zn, Fe, Cu, Mn, Bo (Micro - nutrients); and
  - ✓ pH, EC, OC (Physical parameters).
- Based on this, the SHC will indicate fertilizer recommendations and soil amendment required for the farm.

32.6.8. National Mission on Strategic Knowledge for Climate Change (NMSKCC)

- NMSKCC seeks to build a knowledge system that supports national policy and action for **responding effectively to climate change challenges**, while **not compromising on the nation's growth goals**.
- Mission Objectives:
  - ✓ Formation of knowledge networks engaged in research and development relating to climate science.

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- ✓ Development of national capacity for modelling the regional impact of climate change.
- ✓ Establishing research networks and encouraging research in the areas of climate change impacts on important socio-economic sectors like agriculture, health, ecosystems, biodiversity, coastal zones, etc.

Indian Network on Climate Change Assessment

- Launched by MoEF in an effort to promote **domestic research on climate change**.
- Reports prepared by the INCCA will form a part of India's **National Communication (Nat Com)** to the United Nations Framework Convention on Climate Change (UNFCCC).

National Communication (NATCOM)

- In pursuance of the implementation of the provisions of UNFCCC, India's Initial National Communication (NATCOM) has been initiated in 2002 funded by the **Global Environment Facility**.

32.6.9. National Bio-Energy Mission

- The aim of the mission is to push **sustainable development of the renewable energy sector**.
- It will aim at improving energy efficiency in traditional biomass consuming industries, seek to develop a bio-energy city project and provide logistics support to biomass processing units.
- It proposed a GIS-based National Biomass Resource Atlas to map potential biomass regions in the country.
- According to estimates, biomass from agro and agro-industrial residue can potentially generate 25,000 MW of power in India.

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33. Green Revolution, Sustainable and Modern Agricultural Practises

- Rapid growth in food grain production from using **seeds of high yielding variety** (HYV) is termed as Green Revolution.

33.1. India's First Green Revolution

- The high yielding varieties of **wheat and rice** have been the key elements in Indian green revolution.
- Though the term "green revolution" refers to wheat & rice, some agricultural scientists include maize & soyabean where spectacular gains in yield have occurred.
- The use of **HYVs, fertilizers and pesticides, irrigation and mechanization** are the major aspects of the green revolution.

33.1.1. Introduction of High Yielding Varieties (HYV)

- In 1960s, the average national yield of wheat was very low as compared to the wheat yields of agriculturally advanced countries.
- **MS Swaminathan**, former Director General of ICAR (Indian Council of Agricultural Research) stressed the need for reorientation of the entire breeding programme of tall varieties.
- On the request of Indian breeders **Norman E. Borlaug** was invited from Mexico in 1963 by the Government of India to assess the possibilities of using **dwarf varieties** in India.
- **Borlaug** recommended the feasibility of using **semi dwarf wheat of Mexican origin** as the agro-climatic condition prevailing in India are similar to Mexico.
- On his recommendation two semi dwarf varieties namely **Lerma Rajo** and **Sonora-64** were chosen and were released for cultivation in irrigated fields.
- These varieties gave very high yield and brought in revolution in wheat production.
- In 1970, **Norman E. Borlaug** was awarded **Nobel prize** for **"Green Revolution"** which also helped India.
- Through extensive wheat breeding programmes carried out during 1970-80, new amber seeded, high yielding dwarf wheat varieties were developed.
- The important high yielding varieties responded favourably to **fertilizer** and **irrigation**.

33.1.2. Use of Chemical Fertilizers and Pesticides

- Pesticides are chemicals which have been developed to control organisms called pests.
- **Nitrogenous fertilizers:** **ammonium sulphate**, **ammonium nitrate** and **urea**.
- **Phosphate fertilizers:** **ammonium phosphate**, **calcium dihydrogen phosphate (superphosphate)**.
- **Potassium fertilizers:** **potassium sulphate** and **potassium nitrate**.
- **Nitrogenous fertilizers** ➔ **promotes plant growth**.
- **Phosphate fertilizers containing phosphorous** ➔ help in **root development, plant maturation** and **seed development**.
- **Potassium fertilizers** ➔ **improves plants' abilities to resist disease**. It also **protects the plant when the weather is cold or dry**, strengthening its root system and **preventing wilt**.

33.1.3. Mechanization of Agriculture

- Increase in productivity on large areas of land brought the idea of farm mechanization.

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- To cope up with the shortage of agricultural labour, farm mechanization was the obvious choice for completing agricultural operations.
- The machines which perform various jobs at the farm are water pump, ploughs, combine harvesters, land levellers, cultivators, power operated tractor sprays, reapers, threshers, trolleys and mechanical pickers etc.

33.1.4. Irrigation

- HYVs **require a lot of water** & hence irrigational facilities were a prerequisite for green revolution.
- **Wells:** There are two types of wells, namely **dug wells** and **tube wells**. This kind of irrigation is widely practiced in **plain regions of India**. Overexploitation of wells is well observed in **Punjab-Haryana region**.
- **Canals:** This is usually an elaborate and extensive irrigation system. In this system canals receive water from one or more reservoirs or from rivers. Canal irrigation is well suited for **regions with clayey soil** as **clayey soil prevents water percolation**. Mostly practiced in **south India and Ganga-Yamuna region**.
- **River Lift Systems:** In areas where canal flow is insufficient or irregular due to inadequate reservoir release, the lift system is more rational. Water is directly drawn from the rivers for supplementing irrigation in areas close to rivers. Mostly practiced in **South India**.
- **Tanks:** These are small storage reservoirs, which intercept and store the run-off of smaller catchment areas.

33.2. Second Green Revolution for Sustainable Livelihood

- The first Green Revolution was to ensure food security as there was severe scarcity of food in the country. The second Green Revolution aims at creating **sustainable agriculture** by leveraging advancements in technology.

33.2.1. Need for the Second Green Revolution

- With the growing population and over-exploitation of land resources, the **pressure on food security** will continue and rise.
- 65% of the population is still living in the villages and over 70% of the rural people are dependent on agriculture for their livelihood.
- **Green Revolution, launched in mid-1960s**, was mainly **confined to well irrigated areas**.
- It was **not successful in rain-fed areas**, which contribute significantly to the total food-grain production.
- The Green Revolution has made us **self-sufficient in food grains**, but the **environmental consequences** and ecological costs are offsetting the progress made.
- The **ground water is depleted and polluted**. The lakes and ponds are becoming life less due to **eutrophication – a direct consequence of Green Revolution**.
- Growth in the agricultural sector has been almost stagnant.
- **GM Crops** are marred in various controversies related to **intellectual property, ecological consequences, health consequences** etc.
- **Global warming** is said to **engulf productive coastal lands** due to rise in sea levels. This creates an urgent need to raise and diversify agricultural productivity.

Q. What are the major factors responsible for making rice-wheat system a success? In spite of this success how has this system become bane in India? (UPSC CSE Mains 2020 – 150 words).

Q. How was India benefited from the contributions of Sir M. Visvesvaraya and Dr. M. S. Swaminathan in the fields of water engineering & agricultural science respectively? (2019)

33.2.2. What We Want from Second Green Revolution

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- Improving agricultural production while generating gainful self-employment for the small farmers and weaker sections of the society.
- Scaling up food production **without disturbing the ecological balance**.
- Boosting agricultural development, women empowerment, and environmental protection. (Women are the major power in agriculture as about 65-70% of the labour in crop production is contributed by women).
- **Reclaiming degraded and low fertile lands** and **lands deprived of irrigation**.

33.2.3. Bringing Green Revolution in Eastern India (BGREI)

- Green Revolution that turned India from **'begging bowl'** to leading producer of food-grains.
- BGREI is about binging similar benefits to **eastern India** that largely remained untouched of the wonder that converted the north-west into a 'grain bowl'.
- BGREI is flagship programme under **Rashtriya Krishi Vikas Yojana (RKVY)**. It was announced in the Union Budget, 2010-11. It is intended to address the constraints limiting the productivity of **"rice-based cropping systems"**.
- BGREI focuses on bringing the **Green Revolution (second) to Seven North-Eastern States**, which have rich water resources — **Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, Eastern UP** and **West Bengal**.
- Objective: yield maximization of **rice and wheat** per unit area by improving agronomy, **water harvesting and conservation**; and water utilization.

Government Initiatives to Strengthen BGREI

- The ICAR has established **IARI, Hazaribagh in Jharkhand** and **Indian Institute of Agricultural Biotechnology, Ranchi**.
- It has also established **National Research Centre for Integrated Farming** at **Motihari, Bihar** to further strengthen agricultural research for the eastern region.

33.2.4. Making Second Green Revolution a Success

Precision Agriculture

- The **wealth of data** if harnessed appropriately, can help farmers make the most efficient use of vital inputs such as water and fertilizer by applying them in precise amounts.
- Testing of samples of soil from agricultural fields is vital for achieving **nutrient stewardship**.
- Mobile-based applications for farmers will form an important part of the **data-driven precision agriculture approach**.

Efficient Use of Water

- **Laser levelling** is a technology that can grade an agricultural field to a flat surface by using a laser-guided scraper.
- Laser levelling has been shown to **improve crop yields, reduce labour time spent weeding**, and reduce **water use for irrigation by up to 20-25 per cent**.
- Developing additional water sources through tube wells, dug wells and farm ponds.
- Promotion of Flood, Drought, and Salinity tolerant rice varieties.
- Use of Drum seeders for timely planting of direct seeded rice.

Sustainable Agricultural Practices

- Cultivation practices to increase biological & economic stability.
- Selection of improved varieties to suit the need.
- Soil management by proper method of tillage.

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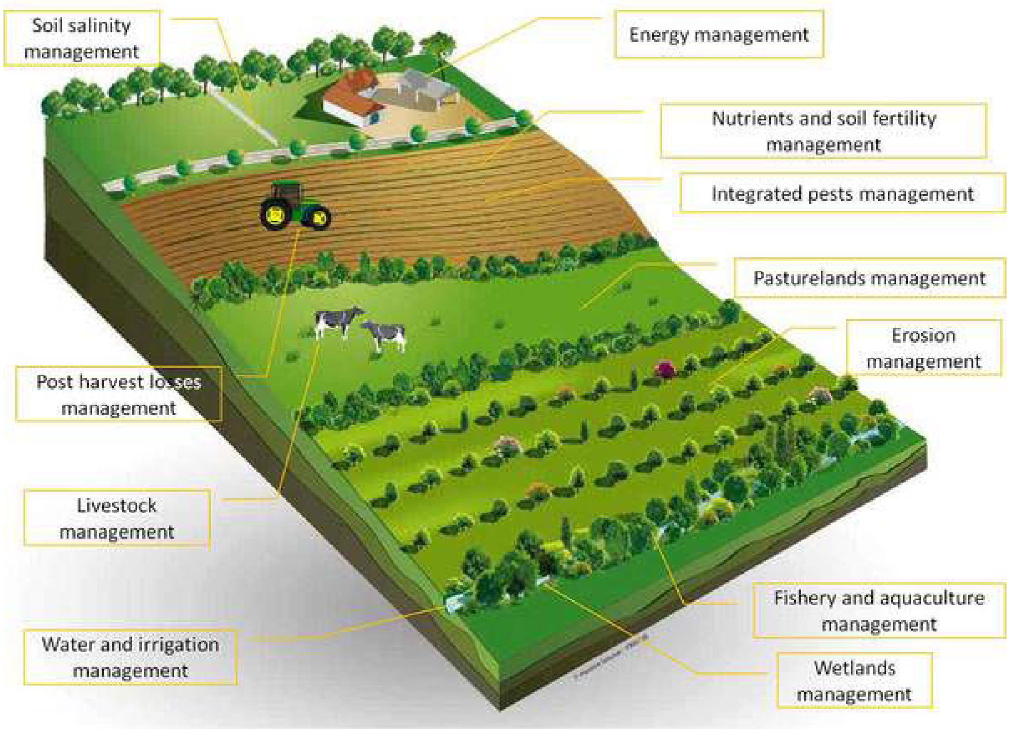
- Organic farming.

Q. Explain various types of revolutions, took place in Agriculture after Independence in India. How have these revolutions helped in poverty alleviation and food security in India? (2017)

33.3. The Concept of Sustainable Agriculture

- Agriculture is a broad term encompassing all aspects of crop production (food and fibre), livestock farming, fisheries, forestry etc.
- Food and fibre productivity have increased by using new technologies, mechanization, increased use of fertilizers and pesticides and expansion of irrigation facilities.
- These changes reduced the labour demand to produce the majority of the food and fibre.
- Although these changes have had the positive effect, they also caused **some serious environmental and social problems** such as **erosion of top soil, depletion and pollution of groundwater** and other water resources, unemployment of farm laborers due to their replacement by farm machinery.
- In view of the growing negative consequences of modern agriculture there is growing demand to promote "sustainable agriculture".



- Sustainable agriculture is the production of food, fibre, plant or animal products using **farming techniques that protect the environment, public health, human and animal welfare**.
- Sustainable agriculture incorporates many **environmentally safe agricultural practices** and offers economically viable opportunities for farmers, laborers, consumers, and others in the entire food system.
- Sustainable farming systems are those that are **least toxic and least energy intensive** and yet maintain productivity and profitability. E.g., **Organic farming** and to an extent **precision farming**.
- Thus, sustainable agriculture is one that,
  - ✓ **supports profitable production;**
  - ✓ **protects environmental quality;**
  - ✓ **uses natural resources efficiently;**
  - ✓ **provides consumers with affordable, high-quality products;**

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- ✓ **decreases dependency on non-renewable resources;**
- ✓ **enhances the quality of life for farmers and rural communities; and**
- ✓ **will last for generations to come.**

33.4. Zero-Budget Natural Farming (ZBNF)

- In India, the Green Revolution led to extensive water consumption and aggravated groundwater loss.
- According to the Central Water Commission, the **agriculture sector already consumed over 83 percent of the available water resources**.
- In the recent past, there was a global demand to shift to sustainable farming systems, such as ZBNF.
- **India introduced ZBNF in its Union Budget 2019-20**.
- ZBNF was first propagated 25 years ago by **Subhash Palekar** (was conferred with Padma Shri by GOI in 2016) as a movement for farmers who were in debt due to the Green Revolution.
- ZBNF is a form of **natural (traditional) farming** which is **neither chemical-loaded nor organic**.
- The ZBNF method promotes:
  - ✓ **Soil aeration,**
  - ✓ **Minimal watering (saves electricity),**
  - ✓ **Intercropping,**
  - ✓ **Bunds and topsoil mulching and**
  - ✓ **Discourages intensive irrigation and deep ploughing**.
- ZBNF seeks to **bring down input costs** by encouraging farmers to rely upon "**natural products" available locally**, rather than spending money on pesticides and fertilizers.
- It is considered 'zero budget' because there is **not much need to spend money on inputs** and **costs of raising the main crop are offset by the income that farmers earn from intercrops**.

33.4.1. Components of ZBNF

- In ZBNF, chemical fertilizers and pesticides make way for **locally available cow dung, cow urine**, jaggery, etc. and treating of seeds with natural ingredients made on the farm by the farmer himself.
- ZBNF promotes the application of
  - ✓ **Jivamrita/jeevamrutha:** it is a **fermented microbial culture**. It provides nutrients and acts as a **catalytic agent** that **promotes the activity of microorganisms** and **earthworms** in the soil.
  - ✓ Palekar **opposes the use of vermicompost**. He recomedns the revival of local deep soil earthworms through increased organic matter.
  - ✓ Jeevamrutha also helps to prevent fungal and bacterial plant diseases.
  - ✓ **Bijamrita:** Bijamrita is effective in **protecting young roots from fungus** as well as from soil-borne and seed borne diseases.
  - ✓ Both Jeevamrutha and Bijamrita are prepared from a mixture of **desi cow dung & urine, jaggery**, etc.
  - ✓ **Acchadana/Mulching**: a protective layer of biomass on soil.
  - ✓ **Whapasa/Moisture**: Whapasa is the condition where there are **both air molecules and water molecules present in the soil**. It involves reducing irrigation, irrigating only at noon, in alternate furrows.
- Also, ZBNF includes three methods of insect and pest management: **Agniastra, Brahmastra, and Neemastra** (preparations using cow urine, cow dung, tobacco, fruits, green chili, garlic, and neem).

Mixed cropping or Diverse cropping

- In mixed cropping or diverse cropping **two or more crops are grown all at the same time in a field**.

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- If by chance one crop fails, the other crops cover the risk of total crop failure.
- Usually a long duration crop is grown with a short duration one so that both get sufficient nutrition at the time of maturity.
- Generally, a leguminous crop is grown along with the main crop. Legumes helps to increase soil fertility by fixing atmospheric nitrogen.
- The various plans followed in diverse or mixed cropping practices are:
  - ✓ **polyvarietal cultivation** where **several genetic varieties** of the same crop are planted.
  - ✓ **intercropping** where two or more different crops are grown at the same time, like carbohydrate rich cereal that uses soil nitrogen and nitrogen fixing legume that puts back the nitrogen in the soil.
  - ✓ **polyculture**, in which different **plants maturing at various times** are planted together.

Advantages of Mixed cropping

- This practice has many advantages because fertilizer and water requirement of plants are different so there is less need of these inputs.
- Pests are controlled naturally because their natural predators find multiple habitats to survive.
- It has been found that this practice produces much higher yield per hectare compared to monoculture.

Monoculture

- Large scale mechanization led to the spread of monoculture i.e., only one crop variety is sown in the entire area when only one cultivator is planted in a large area.
- This system (monoculture) uses lot of fertilizer, pesticide, water.
- This practice may be productive for some time but causes environmental and economic problems.
- E.g. Paddy and wheat cultivation.

Strip Farming

- This involves planting the main crops in widely spaced rows and filling in the spaces with another crop to ensure complete ground cover.
- The ground is completely covered so it retards water flow which thus soaks down into the soil, consequently **reducing erosion problems**.

33.4.2. Other Sustainable Practises for ZBNF & Agriculture in General

Crop rotation

- It is practice of growing **different crops in regular succession** in the same field.
- This practice controls insects and diseases, increases soil fertility and decreases soil erosion.
- Generally, soil cannot sustain continuous cropping with high yielding single crop because certain nutrients required by the crop get exhausted totally while others remain unutilized leading to serious **nutrients imbalance** in soil and encouraging certain diseases and pests.
- Sowing a leguminous crop (e.g., green gram) as a rotational crop is very useful because **legumes enhance nitrogen level in the soil, reduces the need for chemical nitrogen fertilizer**.
- It is possible to grow two or sometimes three different crops in succession on the same land within a year is known as **multiple cropping**.
- This practice can go on for some time, but the land cannot maintain high yield in the long run.

Crop rotation takes into amount the following factors:

- Leguminous crop should be grown after non-leguminous crop.

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- Crops require less water (irrigation) should be grown after one that requires more water.
- Crops requiring less manure should be sown after one that requires more manure.

Mixed Farming

- Optimum diversity may be obtained by integrating **both crops and livestock** in the same farming operation.
- Mixed crop along with livestock operations have several advantages.
- Growing crops only on more level land and pastures or forages on steeper slopes will reduce soil erosion.
- Pasture and leguminous forage crops in rotation enhance soil quality and reduce erosion; livestock manure, in turn, contributes to soil fertility.
- Livestock can buffer the negative impacts of low rainfall periods by consuming crop residue which in "plant only" systems would have been considered crop failure.
- Feeding and marketing are flexible in animal production systems. This can help cushion farmers against price fluctuations and, make more efficient use of farm labour.

Soil Management

- A healthy soil is a key component of sustainable agriculture. That is healthy soil along with water and nutrients produces healthy crops that are less susceptible to pests and diseases.
- Accordingly, soil must be protected and nurtured to ensure long term productivity and stability.
- Methods of protection include using **cover crops, compost, reducing tillage, conserving soil moisture by dead mulches, this increases water hold capacity of the soil**.

Vermicomposting (Palekar opposes the use of vermicompost in ZBNF)

- Vermicomposting is an appropriate technique for efficient recycling of animal wastes, crop residues and agro-industrial wastes.
- The process of conversion of organic materials into manure is chiefly microbiological.
- **Earthworms** are important for producing vermicompost from organic wastes.
- Vermicompost can be prepared from all sorts of organic residues – animal waste, sericulture residues, dairy and poultry residues, bagasse from sugarcane factories, weeds (particularly Parthenium hysterophorus or Congress weed before flowering) etc.

Nutrient Management

- There are **sixteen nutrients** which are essential for plants.
- Air supplies carbon and oxygen, hydrogen comes from water, and soil supplies the other thirteen nutrients to plants.
- Amongst these **thirteen nutrients**, **six are required in large quantities** and are therefore called **macronutrients**.
- The other seven nutrients are used by plants in small quantities and are therefore called **micronutrients**.
- Deficiency of these nutrients affects physiological processes in plants including reproduction, growth and susceptibility to diseases.

Source	Nutrient
Air	carbon, oxygen
Water	hydrogen, oxygen
Soil	⇨ **Macronutrients:** Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur ⇨ **Micronutrients:** Iron, Manganese, Boron, Zinc, Copper, Molybdenum, Chlorine

Nitrogen (N)

- N is an essential constituent of proteins and is present in many other compounds of great physiological importance in plant metabolism.

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- N is an **integral part of chlorophyll**, which is primary observer of light energy needed for photosynthesis.
- N also imparts **vigorous vegetative growth** and **dark green colour to plants**.

Phosphorus (P)

- Phosphorus (P) is an essential part of the enzymes which help the crop to **fix light energy**.
- It forms an integral part of nucleic acids, the carriers of genetic information, and is important in **stimulating root growth**.

Potassium (K)

- Potassium (K) is involved in processes which ensure **carbon assimilation and the transportation** throughout the plant for growth and the storage of sugars and proteins.
- The potassium ion is also important for **water regulation and uptake**.
- Furthermore, the presence of potassium in sufficient amounts ensures resistance to frost, drought and certain diseases.

Others

- **Magnesium** occurs in chlorophyll and is also an **activator of enzymes**.
- **Sulphur** forms part of two **essential amino acids** which are among the many building blocks of protein. It is also found in vitamin B1 and in several important enzymes.
- **Calcium** is required for plant growth, **cell division and enlargement**.
- The **growth of root and shoot tips and storage organs** is also affected by **calcium** as it is a component of cell membranes. Calcium is also vital for pollen growth and to prevent leaf fall.

33.5. Organic Farming

- Organic farming is a type of agriculture or farming **which avoids the use of synthetic fertilizers, pesticides, growth regulators, & livestock feed additives**.
- Organic farming systems rely on **crop rotation, crop residues, animal manures, legumes, green manure, off-farm organic wastes & biofertilizers, mineral bearing rocks to maintain soil productivity**, etc.

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- Organic farmers build healthy soils by nourishing the microbial inhabitants that release, transform, and transfer nutrients. Soil organic matter contributes to good soil structure and **water-holding capacity**.
- Organic farmers feed soil biota and build soil organic matter with cover crops, compost, and biologically based soil amendments.
- Organic farmers' primary strategy in controlling pests and diseases is prevention through good plant nutrition and management.
- Organic farmers use cover crops and sophisticated crop rotations to change the field ecology, effectively **disrupting habitat for weeds, insects, and disease organisms**.
- Weeds are controlled through crop rotation, mechanical tillage, and hand-weeding, as well as through cover crops, mulches, flame weeding, and other management methods.
- Organic farmers rely on a diverse population of soil organisms, beneficial insects, and birds to keep pests in check.
- When pest populations get out of balance, growers implement a variety of strategies such as the use of insect predators, mating disruption, traps and barriers.

33.5.1. The Present Status of Organic Farming in India

- **India ranks first in number of organic farmers** & **ninth in terms of area under organic farming!**
- In January 2016, **Sikkim became India's first "100 percent organic" State**.
- **Lakshadweep** is the **first Union Territory to become 100 per cent organic.**
- States including Tripura & Uttarakhand have set similar targets.
- **The Northeast** has traditionally been organic, & the consumption of chemicals is far less than rest of India.
- About 2.78 million hectares of farmland is under organic cultivation.
- This is **two per cent** of the 140.1 million ha **net sown area** in the country.
- **Madhya Pradesh** tops the list with 0.76 million ha of area under **organic cultivation** — that is over **27 per cent of India's total organic cultivation area.**
- The top three states — **Madhya Pradesh, Rajasthan, & Maharashtra** — account for about half the area under organic cultivation.
- Major organic exports from India are flax seeds, sesame, soybean, tea, medicinal plants, rice & pulses.
- Major exporting states: Assam, Mizoram, Manipur, & Nagaland.

Q. Sikkim is the first 'Organic State' in India. What are the ecological and economic benefits of Organic State? (2017)

33.5.2. Initiatives to promote Organic Farming in India

- Schemes launched to promote organic farming:
  1. **Mission Organic Value Chain Development for North East Region (MOVCD)** &
  2. **Paramparagat Krishi Vikas Yojana (PKVY)**.
- Both PKVY & MOVCD are promoting certification under **Participatory Guarantee System (PGS)** & **National Program for Organic Production (NPOP)** respectively targeting domestic & exports markets.
- The Food Safety & Standards (Organic Foods) Regulations, 2017 are based on the standards of NPOP & PGS.
- The consumer should look for the logos of FSSAI, **Jaivik Bharat/PGS Organic India** on the produce to establish the organic authenticity of the produce.
- **PGS Green** is given to chemical free produce **under transition to 'organic' which takes 3 years**.
- The organic e-commerce platform **www.jaivikkheti.in** is being strengthened for directly linking farmers with retail as well as bulk buyers.

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Mission Organic Value Chain Development for North East Region (MOVCD-NER)

- MOVCD-NER is a **Central Sector Scheme.**
- It is a sub-mission under National Mission for Sustainable Agriculture (NMSA)**.**
- It was launched by the **Ministry of Agriculture & Farmers Welfare** for implementation in the all the North-Eastern states including Sikkim during the 12th plan period.
- The scheme **aims to development of certified organic production** in a value chain mode to link growers with consumers.
- The scheme supports the development of entire value chain starting from inputs, seeds, certification, to the creation of facilities for collection, aggregation, processing, marketing & brand building initiative.

Paramparagat Krishi Vikas Yojna (PKVY)

- PKVY is a **sub-component of Soil Health Management (SHM) scheme under** National Mission of Sustainable Agriculture (NMSA)**.**
- It aims at development of organic farming through a mix of traditional wisdom & modern science.
- It aims to ensure long term soil fertility build-up, resource conservation & helps in climate change adaptation & mitigation.

National Programme for Organic Production (NPOP)

- The **Ministry of Industries & Commerce** is implementing the NPOP since 2001 with the following objectives:
  1. To provide the means of **evaluation of certification programme for organic agriculture** & products.
  2. To accredit certification programmes of Certification Bodies seeking accreditation.
  3. To facilitate the certification of organic products in conformity with the prescribed standards.
  4. To facilitate organic certification in conformity with the importing countries organic standards.
  5. To encourage the development of organic farming & organic processing.
- The **Agricultural & Processed Food Products Export Development Authority (APEDA)** is the implementation agency for the NPOP.
- APEDA is providing assistance to the exporters of organic products under various components of its export promotion scheme.

Participatory Guarantee Scheme (PGS)

- **Union Agriculture Ministry** introduced PGS to incentivise more farmers to grow organic food.

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- PGS is an Operational Manual for **Domestic Organic Certification** published by the **National Centre of Organic Farming, Ghaziabad**.
- PGS is a process in which people in similar situations (small producers) assess, inspect, & verify the production practices of each other & take decisions on organic certification.
- **PGS operates outside the framework of third-party certification**.

Advantages of PGS over third-party certification

- Procedures are simple, documents are basic, & farmers understand the local language used.
- As all members are practising organic farmers themselves, they understand the processes well.
- Because peer appraisers live in the same village, they have better access to surveillance & the **costs are low**.
- Mutual recognition between regional PGS groups ensures better networking for marketing.
- Unlike the grower group certification system, PGS offers every farmer **individual certificate**, & the **farmer is free to market his own produce independent of the group**.
- PGS ensures traceability until the product is in the custody of the PGS group, which makes PGS **ideal for local direct sales & direct trade between producers & consumers**.

Limitations of PGS

- PGS certification is only for farmers that can organise as a group & is applicable only to activities such as crop production, processing, & livestock rearing, & off-farm processing by PGS farmers of their products.
- **Individual farmers or group of farmers smaller than five members are not covered under PGS**.
- They either have to opt for third party certification or join the existing PGS local group.
- PGS is not ideal for furthering organic exports due to **apprehensions over peer-based certification**.

33.5.3. Large Area Certification

- Department of Agriculture under its scheme of Paramparagat Krishi Vikas Yojna (PKVY) has launched a **quick certification programme** "**Large Area Certification**" (LAC) **to harness potential organic areas**.
- Under LAC, each village in the area is considered as one cluster/group.
- All farmers with their farmland need to adhere to the standard requirements & can get certified en-mass.
- Certification is **renewed on annual basis** by a process of **peer appraisals** as per the process of PGS-India.
- Under the scheme, **individual farmers can avail financial assistance** for certification under any of the prevailing certification systems of NPOP or **PGS-India**.

Advantages of LAC Over Old Certification Process

- **As per the established norm of organic production systems:**
  - ✓ The areas having **chemical input usage history** are required to undergo a **transition period of minimum 2-3 years** to qualify as organic.
  - ✓ During this period, farmers need to adopt standard organic agriculture practices & keep their farms under the certification process.
  - ✓ On successful completion, such farms can be certified as organic after 2-3 years.
  - ✓ The process also requires elaborate documentation & time to time verification by authorities.
- Whereas under **LAC requirements are simple & the area can be certified almost immediately**.
- LAC is a **quick certification process that is cost-effective, & farmers do not have to wait for 2-3 years for marketing** PGS organic certified **products**.

Why were Car Nicobar & Nancowry group of Islands certified LAC?

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- Government has certified 14,491 ha of area of **Car Nicobar & Nancowry group of islands** in UT of A&N Islands under the **'Large Area Certification' (LAC) scheme** of the PGS-India (Participatory Guarantee System) certification programme.
- **Car Nicobar & Nancowry group of Islands have been traditionally organic for ages.**
- GOI has also banned the sale, purchase & usage of any chemical inputs or GMO seeds in these islands.
- An expert committee has verified their organic status & recommended for declaration of the area as certified organic under the PGS-India certification programme.

33.5.4. Summary

- Lakshadweep is the **first Union Territory to become 100 per cent organic.**
- In January 2016, **Sikkim became India's first "100 percent organic" State**.
- Organic farming avoids use of synthetic fertilizers, pesticides, growth regulators, & livestock feed additives.
- Organic farming relies on crop rotation, crop and animal residues, biofertilizers, mineral rocks for fertility, etc.
- **India ranks first in number of organic farmers & ninth in terms of area under organic farming.**
- **North East India has traditionally been organic**.
- About 2.78 million ha (**2%** of 140.1 million ha **net sown area**) of farmland is under organic cultivation.
- **Madhya Pradesh** tops the list with 0.76 million ha (27% **of India's organic area**) under **organic cultivation**.
- The top three states — **Madhya Pradesh, Rajasthan, & Maharashtra**.
- Schemes launched to promote organic farming:
  1. **Mission Organic Value Chain Development for North East Region (MOVCD-NER)** &
  2. **Paramparagat Krishi Vikas Yojana (PKVY)**.
- Both PKVY & MOVCD are promoting certification under **PGS** & **NPOP** schemes.
- The consumer should look for the logos of FSSAI, **Jaivik Bharat/PGS Organic India** on the produce.
- MOVCD-NER by **Ministry of Agriculture** is a **Central Sector Scheme.**
- It is a sub-mission under National Mission for Sustainable Agriculture (NMSA)**.**
- The scheme **aims to development of certified organic production** by linking growers with consumers.
- PKVY is a **sub-component of Soil Health Management (SHM) scheme under** NMSA**.**
- It aims at development of organic farming through a mix of traditional wisdom & modern science.
- The **Ministry of Industries & Commerce** is implementing the **National Programme for Organic Production (NPOP)** since 2001.
- Its objective is to provide the means of **evaluation of certification** for organic agriculture products.
- The **Agricultural & Processed Food Products Export Development Authority (APEDA)** is the implementation agency for the NPOP.
- **Union Agriculture Ministry** introduced **Participatory Guarantee Scheme (PGS)** to incentivise more farmers to grow organic food.
- PGS is an Operational Manual for **Domestic Organic Certification** published by the **National Centre of Organic Farming, Ghaziabad**.
- **PGS is a peer-based certification** & **operates outside the framework of third-party certification**.
- PGS offers every farmer **individual certificate**, & the **farmer is free to market his own produce**.
- PGS is **ideal for local direct sales & direct trade between producers & consumers**.
- **Individual farmers or group of farmers smaller than five members are not covered under PGS**.
- PGS is not ideal for furthering organic exports due to **apprehensions over peer-based certification**.

Q. With reference to organic farming in India, consider the following statements: (2018)

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1) The National Programme for Organic Production' (NPOP) is operated under the guidelines and directions of the Union Ministry of Rural Development.
2) The Agricultural and Processed Food Products Export Development Authority' (APEDA) functions as the Secretariat for the implementation of NPOP.
3) Sikkim has become India's first fully organic State.

Which of the statements given above is/are correct?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Answer: b) 2 and 3 only

33.5.5. Bio-Fertilizers are a Key Aspect of Organic Farming

- For a sustainable agriculture system, it is essential to use renewable inputs (fertilizer, pesticides, water etc.) which can benefit the plant and cause no or minimal damage to the environment.
- One of the energy efficient and pollution free method is to exploit the ability of certain microorganisms like **bacteria, algae and fungi** to **fix atmospheric nitrogen, solubilize phosphorus, decompose organic material or oxidize sulphur** in the soil.
- When they are applied in the soil, they enhance growth and yield of crops, improve soil fertility and reduce pollution. They are known as "**bio fertilizers**".
- Thus bio-fertilizers are living or biologically active products or microbial inoculants of bacteria, algae and fungi (separately or in combination) which are able to enrich the soil with nitrogen, phosphorus, organic matter etc.
- Following are some of the important types of bio fertilizers which can be considered for agro based industries.

Rhizobium biofertilizer

- Rhizobium is a **symbiotic bacterium forming root nodules in legume plants**.
- These nodules act as miniature nitrogen production factories in the fields.
- The nodule bacteria **fix more nitrogen (N2)** than needed by legume plant and the bacteria. The surplus fixed nitrogen is then secreted and fertilizes the soil.
- Rhizobium is **more efficient** than-free living nitrogen-fixing bacteria.

Azotobacter biofertilizer

- Azotobacter are **aerobic free living nitrogen fixers**.
- They grow in the **rhizosphere (around the roots)** and **fix atmospheric nitrogen non-symbiotically** and make it available to the particular cereals.
- These bacteria produce **growth promoting hormones** which helps in enhancing growth and yield of the plant.

Azospirillium biofertilizer

- These are **aerobic free living nitrogen fixers** which live in associative symbiosis.
- In this type of association bacteria live on the root surface of the host plant and **do not form any nodule** with roots of grasses.
- It increases crop yield and its inoculation benefits crop.
- They also benefit the host plants by supplying growth hormones and vitamins.
- These bacteria are commonly used for the preparation of commercial inoculants (vaccines, culture medium).

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Blue green algae

- **Blue green algae (cyanobacteria)** like **Nostoc** and **Anabaena** are free living photosynthetic organisms also capable of fixing atmospheric nitrogen.
- In the flooded rice fields blue green algae serves as a nitrogen biofertilizer.

Q. Consider the following organisms

a) Agaricus
b) Nostoc
c) Spirogyra

Which of the above is / are used as biofertilizer / biofertilizers

a) 1 and 2
b) 2 only
c) 2 and 3
d) 3 only

Answer: b) 2 only

Azolla biofertilizers

- Azolla is a water **fern** inside which grows the nitrogen fixing blue green algae **Anabaena**.
- It contains 2-3% nitrogen when wet and also produces organic matter in the soil.
- The Azolla-Anabaena combination type biofertilizer is used all over the world.
- The only constraint in Azolla is that it is an aquatic plant and **water becomes limiting factor** in growing it particularly in summer.

Phosphorus solubilizing biofertilizer

- Phosphorus is an important element required for plant growth. This element is also **needed for nodulation by rhizobium**.
- Some microorganisms are capable of solubilizing immobilized phosphorus making it available to plants for absorption.

Mycorrhizal fungi biofertilizer

- **Mycorrhizal fungi** acts as biofertilizer and are known to occur naturally on roots of forest trees and crop plants.
- Mycorrhizal fungi **resist disease** in plants. The plants also show **drought and salinity resistance**. Plants can **tolerate** adverse soil, pH, high temperature and heavy metal toxicity.
- In soils low in available nutrients there is an increased absorption of nutrients by plants infected with Mycorrhiza. The fungus has the ability to **dissolve and absorb phosphorus** that plant roots cannot readily absorb.

Q. Mycorrhizal biotechnology has been used in rehabilitating degraded sites because mycorrhiza enables the plants to

1) resist drought and increase absorptive area
2) tolerate extremes of pH
3) Resist disease infestation

Select the correct answer using the codes given below:

a) 1 only
b) 2 and 3 only

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c) 1 and 3 only
d) 1, 2 and 3

Answer: d) all

Compost Tea

- Compost Tea is a liquid fertilizer for flowers, vegetables and houseplants.
- Compost tea is an **aerobic** (in the presence of oxygen) water solution that has extracted the microbe population from compost (dead and decaying matter) along with the nutrients.
- In simple terms, it is a concentrated liquid created by a process to increase the numbers of beneficial organisms as an organic approach to plant/soil care.
- Air is sent through the water to keep the water oxygenated, as this favours the beneficial bacteria and fungi over the pathogens. At the end of the brewing cycle, what you have is a concentrated liquid full of billions of microorganisms (bacteria, fungi, protozoa, nematodes) that can then be **sprayed directly** onto the leaf surface.
- The liquid fertilizer occupies the infection sites on the leaf surface and is held there by simple sugars that the plant puts out that work as a glue to keep the beneficial microorganisms thriving and protecting the plant.

Bio char

- Bio char is found in soils around the world as a result of vegetation fires and historic soil management practices.
- Intensive study of bio char-rich dark earths in the Amazon (terra preta), has led to a wider appreciation of bio char's unique properties as a **soil enhancer**.
- Bio char is charcoal that is used as soil amendment (minor improvement).
- It is created using a pyrolysis process (decomposition brought about by high temperatures), **heating biomass in a low oxygen environment**.
- Once the pyrolysis reaction has begun, it is self-sustaining, requiring no outside energy input.
- By-products of the process include **syngas (H_2 + CO)**, minor quantities of methane (CH_4), organic acids and excess heat.
- Once it is produced, bio char is spread on agricultural fields and incorporated into the top layer of soil.
- The syngas and excess heat can be used directly or employed to produce a variety of biofuels.

Agricultural Benefits of Bio char

- It increases crop yields, sometimes substantially if the soil is in poor condition.
- It helps to prevent fertilizer runoff and leeching, allowing the use of less fertilizers.
- It retains moisture, helping plants through periods of drought more easily.
- Most importantly, it replenishes exhausted or marginal soils with organic carbon
- It fosters the growth of soil microbes essential for nutrient absorption, particularly **mycorrhizal fungi**.
- Bio char can increase soil fertility of acidic soils. (The **most fertile soils are slightly acidic**)
- Bio-char reduces the acidity of the soil, protects the plants from diseases, promotes growth of friendly microorganisms, and reduces the loss of micro nutrients apart from increasing water retain-ability.

Kollam, Kerala, is famous for fishing and fishery-related activities; as an agricultural sector, it does not evoke any enthusiasm. Why?

- With the prevailing soil and climatic conditions which favours leaching and draining of soil nutrients into the Arabian sea and Ashtamudi Lake, the **soil has high acidity** making it unfit for cultivation of any kind (friendly microorganisms don't like acidic medium. They like slightly alkaline or basic medium).
- Bio char can make a difference to the agriculture of the region.

Other Environmental Benefits

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- Most carbon in the soil is lost as greenhouse gas (carbon dioxide, CO_2) into the atmosphere if natural ecosystems are converted to agricultural land.
- Soils contain 3.3 times more carbon than the atmosphere.
- This makes soils an important source of greenhouse gases but also a potential sink if right management is applied.
- The use of crop residues for bio-energy production reduces the carbon stocks in cropland.
- Further the dedication of cropland to bio-fuel production increases the area of cultivated land and thus carbon loss from soils and vegetation.
- **Bio char** remains stable for millennia, providing a simple means to **sequester carbon emissions**.
- If bio char is returned to agricultural land it can increase the soil's carbon content permanently and would establish a carbon sink for atmospheric CO_2.

33.6. Modern Agricultural Practices

- Modern agriculture includes animal husbandry, poultry farming, apiculture, fisheries and mushroom culture etc. to provide additional food supplements like milk, meat, fish, egg, mushroom etc.
- In addition to provide nutritional food for the masses, they also reduce load on the consumption of cereals and pulses.

33.6.1. Precision Farming for Productivity and Sustainability

- India's agriculture is focused on production which isn't necessarily translating into productivity & profitability.
- Shrinking land, depleting water and other related resources in agriculture are a serious cause of concern.
- Hence, there is a need for promoting farmer friendly location specific production systems to achieve vertical growth in agriculture with judicious use of natural resources.
- In this regard, precision farming aims to have **efficient utilisation of resources** per unit of time and area for achieving targeted production of agricultural produce.

What is precision farming?

- Precision farming involves **efficient management of resources** through **location specific high-tech interventions**.
- These high-tech interventions include fertigation, greenhouse, soil and leaf nutrient based fertiliser management, mulching for moisture conservation, micro-propagation, high density planting, drip irrigation etc.

Micropropagation

- Micropropagation is the practice of rapidly multiplying a selected plant to produce a large number of progeny plants, using modern plant tissue culture methods.

High density planting

- High density planting technique is a modern method of horticulture involving planting of trees densely, allowing dwarf trees with modified canopy for
  - ✓ better light interception and distribution and
  - ✓ ease of mechanised field operations.
- Control of pests and diseases, weeds and pruning of tree canopy is mostly mechanized.
- Irrigation and fertigation are automatically controlled.
- Such system has low labour requirement and produces high and regular yields of good quality fruits.

- Precision farming uses information based farm management for optimum profitability, sustainability and resource utilization.

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- The required information for Precision farming is obtained with the help of technologies like **geographic information system (GIS), Global Positioning System (GPS), remote sensing (RS)**, etc.
- The success of Precision farming relies on the integration of these technologies into a single system that can be operated at farm level with sustainable effort.

Geoinformatics for Precision Farming

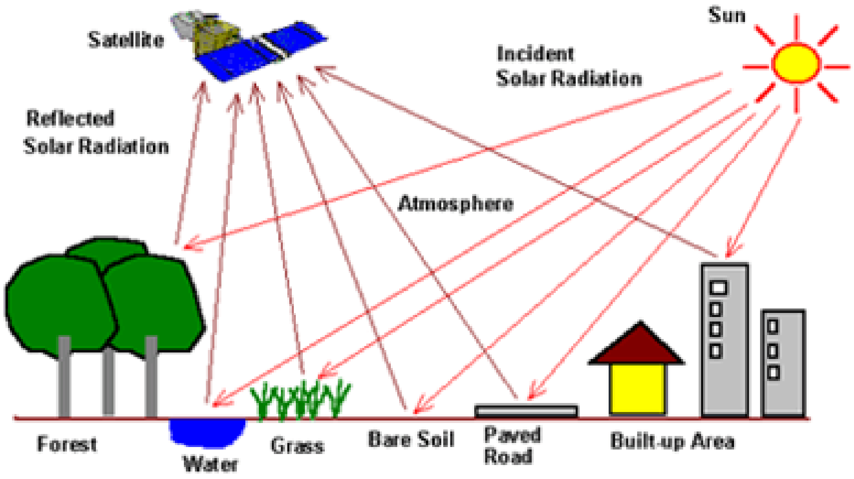
- Geoinformatics deals with integrating computer science & geosciences to solve complex scientific questions.
- It is the science of **gathering, analysing, interpreting, distributing and using geographic information**.
- Geoinformatics encompasses **surveying** and **mapping, RS, GIS, and GPS**.

Global Positioning System (GPS)

- GPS provides continuous, real-time, 3D positioning and navigation worldwide in any weather condition.
- GPS-based applications in precision farming are being used in farm planning, field mapping, tractor guidance, variable rate applications (automated precise application of pesticides, fertilizers, etc. based on data that is collected by sensors, maps, and GPS) and yield mapping.
- GPS allows farmers to work during low visibility field conditions such as rain, dust, fog, and darkness.

Remote Sensing (RS) Technique

- RS is the science of making inferences about material objects from measurements, made at distance, **without coming into physical contact** with the objects under study.
- The RS system consists of a sensor to collect the radiation and a platform — an aircraft, balloon, rocket, satellite — on which a sensor can be mounted.



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- **Remote sensing is precision farming is used for crop yield modelling, identification of pests and disease infestation, soil moisture estimation, irrigation monitoring, assessment of crop damage, etc.**

Q. For the measurement/estimation of which of the following are satellite images/remote sensing data used?

1) Chlorophyll content in the vegetation of a specific location
2) Greenhouse gas emissions from rice paddies of a specific location
3) Land surface temperatures of a specific location

Select the correct answer using the code given below:

a) 1 only
b) 2 and 3 only
c) 3 only
d) 1, 2 and 3

Explanation:

- Various sensors can be used in remote sensing. Sensors may use a wide range of frequencies from radio waves to visible light.
- Methane Sensor for Mars (Mars Orbiter Mission) is a radiometer. It was remotely able to measure columnar **methane (CH_4)** in the Martian atmosphere at several parts per billion (ppb) levels.
- Forest Survey of India uses remote sensing to identify canopy density (uses thermal and high-definition imaging).
- Thermal sensors (uses infrared radiation) can detect GHGs as they trap heat.

Answer: d) all

Geographic Information System (GIS)

- The GIS is a **computerised data storage and retrieval system**, which can be used to manage and analyse spatial data relating crop productivity and agronomic (study of crops and the soils) factors.
- It can integrate all types of information and interface with other decision support tools.
- **GIS can display analysed information in maps** that allow better understanding of interactions among yield, fertility, pests, weeds and other factors, and decision-making based on such spatial relationships.

Internet of things

- The computers and low latency internet (5G) are the most important components in precision farming as they are main source of information processing and gathering.

Future strategy

- Precision farming is practised in developed countries and it not yet practically adoptable in developing countries like India.
- Future strategy for adoption of precision agriculture in India should consider the problem of **land fragmentation, lack of highly sophisticated technical centres for precision agriculture, specific software for precision agriculture, poor economic condition of the farmers,** etc.

Integrated Pest Management (IPM)

- In this approach, each crop and its pests are evaluated as parts of an ecological system.
- Then farmers develop a control programme that includes cultivation, biological and chemical methods applied in proper sequence and with the proper timing.
- The aim of IPM is not to eradicate the pest population completely but to keep the crop damage to economically tolerable level.

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- Farmers monitor the field and when they find the pest level to be high enough, they first use biological methods and cultivation practices to control and then use small amounts of insecticides mostly insecticides derived from plants as a last resort.

Biological control includes

- Natural predators, parasites and pathogens of the pests are used.
- Example: Pest on cucumber plant called red spider mite is controlled by using a predatory mite that feed on red spider mite.

Cultivation practices

- A variety of cultivation practices like crop rotation, polyculture and inter cropping etc. can be used to get rid of the pests.
- Some amounts of insecticides, mostly of plant origin (e.g. Pyrethrum and Rotenone neem product) are applied as a last resort.
- Pest and disease resistant crop plants can be produced by genetic engineering. Example is Bt cotton, insecticidal for bacterial gene (**Bacilus thuringinesis**) introduced into cotton plant making cotton plant resistant to pest.

Disadvantages of Integrated Pest Management (IPM)

- Farmer should have an expert knowledge about each pest.
- It acts more slowly than conventional pesticides.
- Methods developed for a crop in one area might not apply to areas with even slightest different growing conditions.
- Initial cost may be higher but in the long-term cost become very low.

33.6.2. Protected Cultivation of Horticulture Crops

- Protected cultivation practices are cropping techniques wherein the microenvironment is controlled partially/ fully as per plant need during their period of growth to maximize the yield and resource saving.

Geoponic	• refers to growing plants in normal soil
Aeroponics	• growing plants in mist environment without the use of soil medium
Hydroponics	• growing plants using mineral nutrient solutions, in water, without soil.
Aquaponics	• symbiotic environment of aquaculture and hydroponics

Green House

- Green houses are climate controlled with cooling and heating system.
- It is mainly used to grow exotic vegetables, off-season growing of vegetables, floriculture, planting material acclimatization and plant breeding and varietals improvement under adverse agro-climatic conditions.
- The degree of sophistication of greenhouses include fully automated systems with poly carbonate sheet roofing (double walled), heating and cooling systems, etc.

Poly House

- Poly house is less sophisticated version of green house with **naturally ventilated climate controlled as against the fully climate controlled green houses**.
- Usage of poly houses are similar to green houses.

Hydroponics

- Hydroponics is a method of **growing plants without soil**, using water enriched with balance mineral nutrients essential for plant growth and yield.

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- The nutrients and PH level are maintained suiting to the selected crop for better growth.
- With increasing water scarcity due to frequent droughts and declining land availability for farming, government agencies are promoting hydroponic for growing vegetables, fruits and fodder.

Advantages of hydroponics

More yield in a smaller patch of land

- Hydroponics supports **vertical farming** and is ideal to grow crops in congested urban environment.
- Vertical farming: The plants are grown on raised beds that stand a few feet from the ground, making it possible to cultivate several rows on either side of the bed.
- The increase in output happens because the **cropping cycle is reduced, and the plants doesn't have to grow long roots in search of nutrients**.

Allows one to tailor crops as per market demand and this reduces wastage

- In hydroponics, cropping cycle is reduced and harvesting times are a lot shorter.
- In traditional farming, sometimes crops grown are not really required in the market at that point of time. This leads to wasted produce.

Significantly reduced water usage yet superior yield

- Hydroponics systems require only around 10 percent of the water that soil-based agriculture requires.
- In traditional farming, water and nutrients are lost in soil. This leads to groundwater contamination.
- In hydroponics, the nutrient solution is mixed into the water and is supplied directly to the roots.
- Since the water directly reaches the roots, it is absorbed much better and **nothing is lost in soil absorption**.
- The plants are provided with maximum possible nutrients which results in multi-fold growth.

Better quality control and better environment

- Hydroponics reduces transportation cost & emissions.
- Hydroponics makes the **application of organic farming techniques very simpler**.
- Sticky pads and a solar powered insect trap can be used to trap insects. This reduces the use of insecticides.
- Soil-borne diseases and pests are also low as the crops are grown in a closed environment free of soil.
- Also, natural ingredients such as neem oil can be used much more effectively to control pests. This reduces the use of pesticides.

Better nutritional value of crops

- Fodder produced through hydroponics is more nutritional than the regular fodder.
- As food production is closer to the consumer, time is not lost in logistics & hence there is no loss of nutrients.

Better cultivation techniques & application of sci & tech

- The farms can be indoors or outdoors (a greenhouse).

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- Suitable for vertical farming under greenhouse conditions and other modified structures.
- Each hydroponic crop can be given a favourable and individual climatic condition through an automated temperature and humidity controlled greenhouse.
- The farm can be managed remotely using the **internet of things** (IoT – schedule a fertigation session, actively monitor the plants remotely, automated humidity and temperature control, nutrient and input control, etc.).
- The crop can use natural light or artificial lighting (day and night – 24/7 growth period).

Opportunities

- Demand for chemical-free food is increasing with rising awareness among consumers.
- The organic market in India at present is estimated to be $1.3 billion (about Rs 9,000 crore), expected to double by 2021.
- Ministry of Agriculture has subsidy programme for hydroponics.

Disadvantages of Hydroponics

Capital-intensive

- Though hydroponics is typically much cheaper over time, it does require a substantial upfront cost to establish any sort of larger system.

Needs uninterrupted power supply

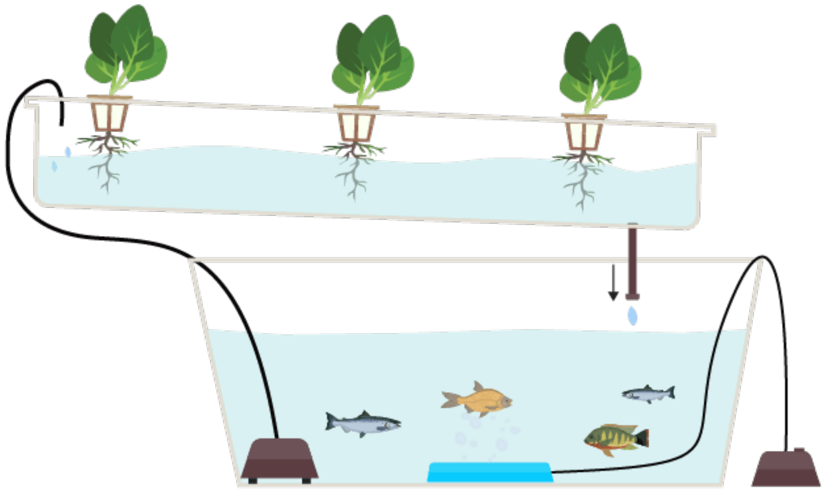
- Power failure can cause pumps and equipment to stop working.

Lack of awareness

- Many people fear that hydroponics requires substantial know-how and research, when in fact, it's very similar to traditional gardening.

Aquaponics

- The method combines aquaculture — **cultivating fish and other aquatic animals in tanks with organic inputs — with hydroponics**, where plants are cultivated in water.



- The water from the fish tank is pumped onto the beds where plants grow.
- While the **fish excretions provide nutrients for the plants** (hence no chemical fertilizers are needed), the clean water is recirculated back to the fish tank.
- While the initial cost to set up the facility would be high, the recurring cost is low in aquaponics.
- The difference between aquaponics and hydroponics is that **synthetic fertilisers are used in hydroponics for providing nutrients to plants and hence cultivation of fish is not possible in hydroponics**.

Aeroponics

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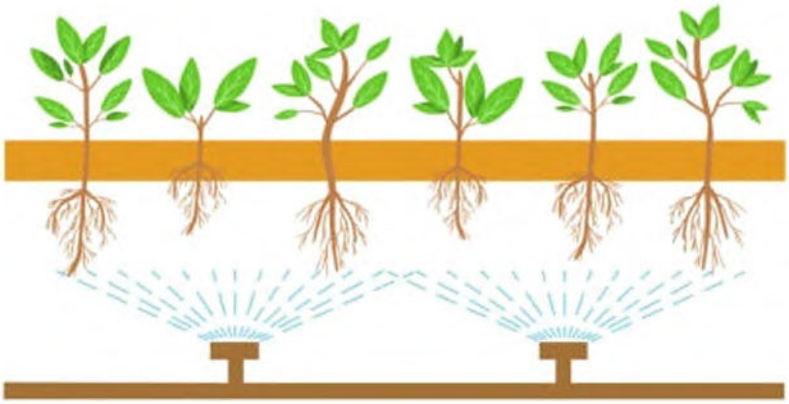
- Unlike in hydroponics, the **roots of plants grown in an aeroponic system are suspended in the air and the spraying of water and nutrients leads to an oxygen-rich, misty environment**.
- Aeroponics has been implemented as an alternative to water intensive hydroponic systems worldwide.



Advantage of aeroponics over hydroponics

- **Aeroponics can limit disease transmission** since plant-to-plant contact is reduced.
- The enhanced oxygen availability at the root zone leaves disease-causing pathogens dormant.
- **Improves uptake of minerals** by plants and development of healthy root systems.
- Helps in faster and better growth of plants with a **plentiful supply of oxygen, water and nutrients**.
- Plants in a true aeroponic conditions have **100% access to the CO_2 concentrations** for photosynthesis.
- This leads to a multi-fold increase in plant metabolism, which in turn results in a **increase in production**.
- Any species of plants can be grown in a true aeroponic system because the microenvironment of an aeroponic can be **finely controlled**.
- Aeroponically grown plants have high dry weight biomass (essential minerals).
- According to NASA, aeroponically grown plants **require ¼ the nutrient input** compared to hydroponics.
- Unlike hydroponically grown plants, aeroponically grown plants **will not suffer transplant shock** when transplanted to soil.

33.6.3. Genetically modified crops (GM Crops or Biotech Crops)

Genetically Modified Organism (Transgenic Organism)

- In GMO, **genetic material (DNA) is altered or artificially introduced** using genetic engineering techniques.
- Genetic modification involves the **mutation, insertion, or deletion of genes.**
- Inserted genes usually come from a different organism (e.g. In Bt cotton, Bt genes from bacterium **Bacillus thuringiensis** are induced).
- Genetic modification is done to induce a desirable **new trait** which does not occur naturally in the species.

GM techniques are used in:

- Biological and medical research,
- Production of pharmaceutical drugs,
- Experimental medicine (e.g. gene therapy),
- Agriculture (e.g. **golden rice,** Bt cotton etc.),
- Genetically modified bacteria to produce the **protein insulin**,
- To produce biofuels from some GM bacteria, etc.

Genetically modified crops

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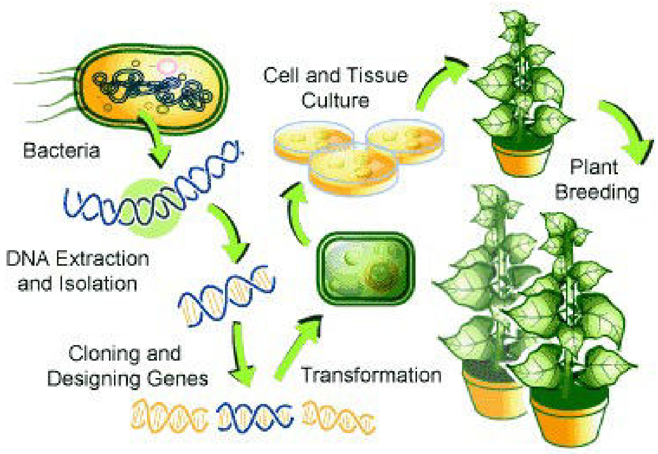

- They are the plants used in agriculture, whose DNA has been modified to induce a desired **new trait**.
- A New trait might help in
  - ✓ Controlling certain pests, diseases, or environmental conditions,
  - ✓ reduction of spoilage,
  - ✓ inducing resistance to chemical treatments (e.g. resistance to an herbicide),
  - ✓ **improving the nutrient profile** of the crop,
  - ✓ atmospheric nitrogen fixation by cereal crops,
  - ✓ inducing tolerance to high salt soils and to flooding in crops,
  - ✓ inducing drought resistance in crops,
  - ✓ prolonging shelf life and commercial value of fruits and vegetables.

Major GM Crops

Bt Cotton

- Bt cotton is insect-resistant cotton variety.
- Strains of the **bacterium Bacillus thuringiensis** produce different **Bt toxins**.
- Bt toxins are insecticidal to the larvae of moths, bollworms, etc. but are harmless to other forms of life.
- In 2002, a joint venture between Monsanto and Mahyco introduced Bt cotton to India.

Advantages

- Increases yield of cotton due to effective control of three types of bollworms.
- Reduction in insecticide use in the cultivation of Bt cotton in which bollworms are major pests.
- Potential reduction in the cost of cultivation (depending on seed cost versus insecticide costs).

Problems with Bt Cotton

- High cost of Bt cotton seeds as compared to non Bt cotton seeds.
- Ineffective against sucking pests like whitefly.
- Whitefly attack has become rampant in Punjab, Haryana and elsewhere.
- The costs of Bt seed and insecticide increase the risk of farmer bankruptcy in low-yield rain-fed settings.

Pink Bollworm

- It is an insect known for being a pest in **cotton** farming.
- It is native to Asia, but has become an invasive species in most of the world's cotton–growing regions.
- It is now **resistant to Bt–cotton** in India.

Bt Brinjal

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- Brinjal is India's second most consumed vegetable after potatoes.
- Bt brinjal is created by inserting a crystal protein gene from the soil bacterium Bacillus thuringiensis.
- The Bt brinjal has been developed to give resistance to the Brinjal Fruit and Shoot Borer (FSB).
- Mahyco has developed the Bt brinjal variety.
- Insecticide requirement for Bt brinjal is far less than its non-Bt counterpart for the control of FSB.
- The Genetic Engineering Appraisal Committee (GEAC) cleared Bt brinjal for commercialization in 2009.
- Following concerns raised by some scientists and anti-GMO activists, the GOI has imposed a moratorium on its commercial use (not a permanent ban).
- Mahyco's Bt brinjal is commercially grown in Bangladesh.

Golden rice

- Golden rice is a variety of rice **(Oryza sativa)** produced to biosynthesize **beta-carotene**, a precursor of **Vitamin A**, in the edible parts of rice.
- It is mostly consumed in areas with a shortage of dietary vitamin A.

Benefits of GMO

Crops

- Enhanced taste and quality.
- Reduced maturation time.
- Increased nutrients, yields, and stress tolerance.
- Improved resistance to disease, pests, and herbicides.
- New products and growing techniques.

Animals

- Increased resistance, productivity, hardness, and feed efficiency.
- Better yields of meat, eggs, and milk.
- Improved animal health and diagnostic methods.

Environment

- "Friendly" bioherbicides and bioinsecticides.
- Conservation of soil, water and energy.
- Bioprocessing for forestry products.
- Better natural waste management.

Society

- Increased food security for growing population.

Issues Surrounding GMO

Safety

- The adverse impacts of genetically modified food are not evident immediately.
- Potential human health impact: allergens, transfer of antibiotic resistance markers, unknown effects.
- Potential environmental impact: unintended transfer of transgenes through crosspollination, unknown effects on other organisms (e.g., soil microbes) and loss of flora and fauna biodiversity.
- **Criticism against Anti-GM lobby:** Instead of evaluating the risks, costs and benefits of hybrids on a case-by-case basis, they propose a blanket ban on genetic modification.

Access and intellectual property

- Domination of world food production by a few companies.

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- Increasing dependence on industrialized nations by developing countries.
- **Biopiracy** — foreign exploitation of natural resources.

Ethics

- Violation of natural organisms' intrinsic values.
- Tampering with nature by mixing genes among species.
- Objections to transferring animal genes in plants and vice versa.

Labelling

- Not mandatory in some countries (e.g. United States).
- Mixing GM crops with non-GM confounds labelling attempts.

Research

- The **objectivity and authenticity** of scientific research and publication.

Effectiveness

- The ineffectiveness of BT cotton against whitefly attack in Punjab and Haryana has raised more questions.

Issues with banning GM crops

- The ban on GM crops is also promoting an illegal market to flourish in India.
- Bangladesh is reaping the benefits of Bt Brinjal while its cultivation is banned in India.

GMO have already entered the food chain

- Cotton seed oil extracted from Bt cotton plants is being consumed in Gujarat and Maharashtra.
- Soybean oil is extracted from imported seeds, which are produced from GM crops abroad.

Illegal cultivation (Farmer's rights vs. Government Regulation)

- A farmers' group in Maharashtra, marked its protest against the government ban on genetically modified (GM) crops by planting Bt brinjal and HT cotton.
- There is a grave danger of illegal genetically modified brinjal cultivation proliferating.

33.6.4. Various Agricultural Activities and Revolutions in Agriculture

Revolution	Economic Activity
Green	Food grain Production
Golden	Horticulture, Fruit, Honey Production
Golden fiber	Jute cultivation
Grey	Fertilizer Production
Blue	Fish Production
Black	Petroleum Production
Brown	Leather production
Pink	Prawn Production / Onion production
Round	Potato Production
Red	Meat / Tomato Production
Silver	Egg / Poultry Production
White	Milk Production
Yellow	Oil seeds Production

Various Agricultural Activities

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Name	Agricultural Activity
Silviculture	• cultivating forest trees
Sericulture	• rearing of silkworms for the production of raw silk
Apiculture	• maintenance of honey bee colonies, commonly in hives, by humans
Olericulture	• science of vegetable growing, non-woody (herbaceous) plants for food
Viticulture	• science, production and study of grapes
Floriculture	• flowering and ornamental plants for gardens
Arboriculture	• cultivation and study of individual trees, shrubs, and other woody plants
Pomology	• focuses on the cultivation, production, harvest, and storage of fruit, etc.
Aeroponics	• growing plants in mist environment without the use of soil medium
Hydroponics	• growing plants using mineral nutrient solutions, in water, without soil.
Geoponic	• refers to growing plants in normal soil
Aquaponics	• symbiotic environment of aquaculture and hydroponics

Mushroom culture

- **Mushrooms are kind of fungus** with a short stem and a cap which opens like an umbrella later.
- They lack chlorophyll and grow on organic matter or waste materials from farms or factories.
- Out of the large number of mushroom species only some are edible.
- Mushrooms are good source of high-quality **proteins** and are rich in vitamins and minerals.
- Like fruits and vegetables mushrooms are perishables.

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34. Sources of Energy

34.1. Conventional and Non-Conventional Sources of Energy

Conventional		Non-Conventional
Conventional Non-Renewable	**Conventional Renewable**	
Mostly fossil fuels found under the ground. ✓ Coal ✓ Oil ✓ Natural Gas ✓ Coalbed Methane	**Mostly non-fossil fuels seen above the ground.** ✓ Firewood ✓ Cattle Dung ✓ Vegetable Waste ✓ Wood Charcoal	1. Solar Energy 2. Hydro Power 3. Wind Energy 4. Nuclear Energy 5. Hydrogen Energy 6. Geothermal Energy 7. Biogas 8. Tidal Energy 9. Biofuel

34.1.1. India Energy Outlook 2021

- Committed to **Nationally Determined Contributions (Paris Accord)**, India made a pledge that **by 2030**, **40% of installed power generation capacity shall be based on clean sources**.
- India attained global **4th and 5th positions** in the **wind,** and **solar** power installed capacities.
- India is in **5th global position** for overall installed **renewable energy capacity**.

Total Installed Power Capacity

Total Installed Power Capacity (As on 30/06/2021)			
Fuel	**MW**	**% of Total as of April 2021**	**% of Total as of Oct 2018**
Total Thermal	**2,34,058**	**60.9% ↓**	63.84%
1. **Coal**	2,02,005	**52.6% ↓**	
2. **Gas**	24,924	6.5%	
3. **Lignite**	6,620	1.7%	
4. **Diesel**	510	0.1%	
Hydro (Renewable)	46,322	**12.1% ↓**	13.09%
Nuclear	6,780	**1.8% ↓**	1.95%
RES* (MNRE)	**95,956**	**24.8% ↑**	21.12%
Total	3,84,116 **(384 GW)**		
1) **Public Sector (52.6%) (Decreasing over time)** 1. **State Sector (27%)** 2. **Central Sector (25.2%)** 2) **Private Sector (47.7%) (Increasing over time)**			**(Exact Numbers are not important. Analyze the trends)** RES* (MNRE): Installed capacity in respect of Renewable Energy Sources (MNRE).

Source: Central Electricity Authority (CEA) | Invest India

Installed Renewable Power Capacity

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Installed renewable power capacity (excluding large hydropower) as of May 2021		
Source	**Total Installed Capacity (GW)**	**2022 target (GW)**
1. Solar power	41.06	**100**
2. Wind power	39.44	**60**
3. Biomass power	10.17	**10**
Waste-to-Power	0.17	
4. Small hydropower	4.79	**5**
TOTAL	**95.66**	**175**

Q. "Access to affordable, reliable, sustainable and modern energy is the sine qua non to achieve Sustainable Development Goals (SDGs)." Comment on the progress made in India in this regard. (2018)

Q. "In spite of adverse environmental impact, coal mining is still inevitable for development". Discuss (2017)

Q. Give an account of the current status and the targets to be achieved pertaining to renewable energy sources in the country. Discuss in brief the importance of National Programme on Light Emitting Diodes (LEDs). (2016)

34.1.2. Major Energy Sources

Fuel	Production	Advantages	Limitations
Nuclear energy	**Nuclear fission** and **Nuclear Fusion**	• No air pollution • Fuel efficient • **No nuclear waste in a nuclear fusion reactor.**	• High cost of construction of nuclear plant. • Security and nuclear accidents. • **Problem of safe disposal of nuclear waste in case of nuclear fission reactors**. • **Nuclear Fusion Reactor** technology remains a hard nut to crack as it is **technologically very challenging.**
Hydropower	Dams built on rivers for electricity generation	• The world's hydroelectricity potential is high. • It is a relatively cheap and clean source of energy.	• Ecosystems behind dams disturbed. • Human settlements uprooted. • Habitat loss and biodiversity loss. • Developmental cost high. • Fertile farmland lost • Amount of nutrient-rich silt on down river agricultural fields reduced.
Solar energy	From natural sunlight	• Environment friendly • Ample or unlimited availability.	• Limited capacity for storage of sunlight. • Diurnal and Seasonal variations and grid management. • Collecting equipment is expensive.
Wind energy	Fans for directing winds in use from long for irrigation crops	• No pollution • Available for free	• Intermittently available. • Fans of wind mills visual hazards for flying birds and aeroplanes (visual pollution).
Tidal energy	Harnessing tidal power by suitable structures	• Free and clean	• Structures (plants) used for harnessing energy are expensive. • Plant disrupts the natural flow of the estuary and concentrates pollutants in the area.
Geothermal energy	Wells are drilled to trap steam which powers electrical generators. Steam is naturally produced from under-	• Environment friendly	• Steam contains **Hydrogen Sulphide** (H_2S), having the odour of rotten eggs. • Minerals in the steam corrosive to pipelines and equipment causing maintenance problems.

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	ground water, which gets heated due to the very high temperature in that region.		• Minerals in the water are toxic to fish.
Biomass	Cutting trees for fuel wood and burning them straight away	• Cheap and hence popular in underdeveloped and developing countries	• Comparatively low level of energy. • Bulky so difficult to transport. • Burning wood causes air pollution. • Destruction of forests to obtain fuel wood and so desertification. • Release lot of fly ash.
Biomass conversion	Obtaining energy from chemical energy. Stored in biomass (or live material). Burned directly for cooking or to produce electricity converted to ethanol or methane (biogas)	• Renew able energy	• May lead to food shortage because nutrients not returned to soil from biomass. • Growing maize for ethanol requires more energy expenditure than the amount of energy in the form of alcohol retrieved. • Land for growing food used for growing biomass for conversion into fuel.
Solid waste	Waste sorted and burnable material separated	• Decreases cost of fresh disposal • Reduces need for land fill sites	• Causes air pollution for burning releases CO_2 and other gases. • Waste such as bleached paper and plastics have **chlorine containing compounds** which form **dioxins** which are highly toxic and suspected to be carcinogenic.

Biomass

- Biomass is a **renewable energy** resource derived from **plant & animal waste**.
- The energy from biomass (biomass conversion) is released on **burning or breaking the chemical bonds of organic molecules** formed during photosynthesis.

Advantages of biomass energy

- **The burning of biomass does not increase atmospheric carbon dioxide (carbon neutral)** because to begin with biomass was formed by atmospheric carbon dioxide, and the same amount of carbon dioxide is released on burning.

Petro Crops (Plants)

- Recent researches suggest that **hydrocarbon producing plants** can become alternative energy sources, which can be inexhaustible and ideal for liquid fuel.
- These plants called **petroplants/petrocrops** can be grown on land which are unfit for agriculture and not covered with forests. **Jatropacurcas** is an important petro plant.
- Biocrude can be obtained by tapping the latex of Jatropacurcas.
- Hydrocracking of biocrude can convert it into several useful products like gasoline (automobile fuel), gas oil and kerosene.
- Some potential Petro-crop species belong to the family **Asclepiadaceae** and **Euphorbiaceae**.

Geothermal Energy

- Geothermal energy is natural heat from the interior of the earth that can be used to generate electricity as well as to heat buildings.

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- In some countries, such as in the USA, water is pumped from underground hot water deposits and used for heating houses.

Geothermal energy in India

- In India, North-western Himalayas and the western coast are considered geothermal areas.
- The **Puga valley in the Ladakh region** has the most promising geothermal field.

Environmental impact of geothermal energy

- The steam contains **hydrogen sulphide gas**, which has the odour of rotten eggs & causes air pollution.
- The minerals in the steam are also toxic to fish, and they are corrosive to pipes and equipment, requiring constant maintenance.

Tidal energy

- The tidal power is harnessed by building a dam **across the entrance to a bay or estuary**.
- As the tide rises, water is initially prevented from entering the bay. Then when tides are high, and water is sufficient to run the turbines, the dam is opened, and water flows through it, turning the blades of turbines.
- Again, when the reservoir (the bay) is filled, the dam is closed, stopping the flow and holding the water in the reservoir when the tide falls (ebb tide), the water level in the reservoir is higher than that in the ocean.
- The dam is then opened to run the turbines (which are reversible), electricity is produced as the water is let out of the reservoir.
- The dams built to harness the tidal power **adversely affect the vegetation and wildlife**.

34.1.3. Calorific Value of Various Sources of Energy

Fuel	Calorific Value in Megajoules/kg
Hydrogen	**141**
Methane (CH_2)	**55**
Ethane (C_2H_6)	52
Natural gas and CNG	**52**
Liquefied petroleum gas (LPG)	**50**
Propane, butane	50, 49
Petrol/gasoline	**46.4**
Kerosene	**46.2**
Diesel fuel	**45.5**
Biodiesel (methyl ester)	**37**
Ethanol (CH_3-CH_2-OH)	29
Methanol (CH_3OH)	23
Coal anthracite has highest – 32; peat has the lowest – 17)	17-32
Firewood (dry)	16

34.2. Solar Energy

- Solar energy can be converted directly into **electrical energy (direct current, DC) by photovoltaic (PV) cells** commonly called solar cells.
- Photovoltaic cells are made of silicon and other materials. When sunlight strikes the silicon atoms, it causes electrons to eject. This principle is called as the **photoelectric effect**.
- A typical solar cell is a transparent wafer that contains a very thin semiconductor.

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- Sunlight energizes and causes electrons in the semiconductor to flow, creating an electrical current.

Q. With reference to technologies for solar power production, consider the following statements:

1. 'Photovoltaics' is a technology that generates electricity by direct conversion of light into electricity, while 'Solar Thermal' is a technology that utilizes the Sun's rays to generate heat which is further used in electricity generation process.
2. Photovoltaics generates Alternating Current (AC), while Solar Thermal generates Direct Current (DC).
3. India has manufacturing base for Solar Thermal technology, but not for Photovoltaics.

Which of the statements given above is / are correct?

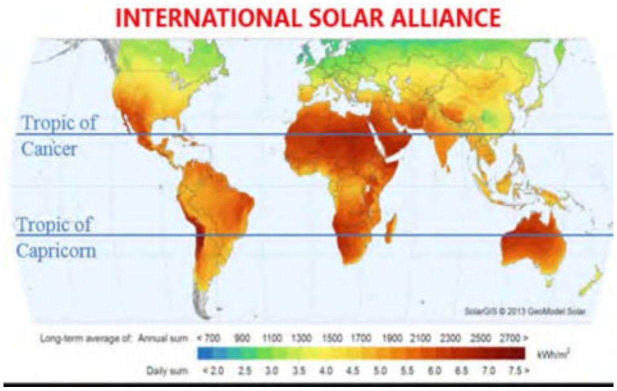
a) 1 only
b) 2 and 3 only
c) 1, 2 and 3
d) None

Explanation:

- **Photoelectric effect** ➔ When light strikes on a material, **electrons are dislodged (photons dislodge electrons)**.
- **Photovoltaic** ➔ The dislodged electrons, if channelled through a conductor, will create electric current (voltage or potential difference) ➔ **Solar Panels**. (Electric current is nothing but the movement of electrons from high potential to low potential area (more electrons to fewer electrons region))
- Solar thermal ➔ converting light into heat ➔ **solar cooker, solar water heater**.
- Photovoltaics generate direct current (DC). (**Rotating = AC, Stationary = DC. Electric generator**, a wind turbine generates AC while solar panels generate DC)
- Solar thermal is mostly used for water heating purposes. Electricity can be generated by using hot water steam to rotate the turbine ➔ AC current.
- In India, both solar panels & solar cookers are manufactured. **Answer: a) 1 only**

34.2.2. International Solar Alliance

- The **International Solar Alliance (ISA)** is an alliance was initiated by **India**.
- It was initiated at the **India Africa Summit** and a meeting of member countries ahead of the Paris Summit.
- It was **established through Paris Declaration**.
- The framework agreement opened for signatures in Marrakech in 2016, and 122 countries have joined.
- Most of the 122 countries are **sunshine countries**, which lie either **completely or partly** between the **Tropic of Cancer and the Tropic of Capricorn**.



- ISA is now **extended to all members of the UN** and is now a treaty-based inter-governmental organization.
- **Countries that do not fall within the Tropics can join** the alliance **with the exception of voting rights**.

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- The primary objective of the alliance is to work for **efficient exploitation of solar energy to reduce dependence on fossil fuels**.
- It will **not duplicate or replicate the efforts** that others are currently engaged in but will establish networks and **develop synergies with them and supplement their efforts** in a sustainable manner.
  - ✓ International Renewable Energy Agency (IRENA),
  - ✓ Renewable Energy and Energy Efficiency Partnership (REEEP),
  - ✓ International Energy Agency (IEA),
  - ✓ Renewable Energy Policy Network for the 21st Century (REN21),
  - ✓ United Nations bodies, bilateral organizations etc.
- International Solar Alliance (ISA) aims to create a **World Solar Bank** with an authorized capital of **$15 billion** to fund projects.
- It also aims to mobilize investments of more than **USD 1000 billion by 2030**.
- Headquarters: **Gurugram, Haryana, India**.

Targets

- The ISA has set a target of **1000 GW of solar energy by 2030**.
- India has set a target of **175 GW of renewable energy capacity by 2022**, which includes **100 GW of solar energy**.

Delhi Solar Agenda

- Delhi Solar Agenda was **adopted in the Founding Conference** of the ISA.
- It states that the ISA member States inter-alia have agreed to pursue an increased share of solar energy in the final energy consumption in the respective national energy mix.
- ISA has six programmes viz. Solar Applications for Agricultural Use, Affordable Finance at Scale, Mini Grids, and Solar Rooftops and Solar E-mobility & Storage and Large-Scale Solar Parks.

Q. Consider the following statements: (2016)

1) The International Solar Alliance was launched at the United Nations Climate Change Conference in 2015.
2) The Alliance includes all the member countries of the United Nations.

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Answer: a) 1 only

34.2.3. One Sun One World One Grid (OSOWOG)

- **OSOWOG** is **India's initiative** to build a **global ecosystem** of **interconnected renewable energy resources**.
- The blueprint for the OSOWOG will be developed under the **World Bank's** technical assistance programme that is implemented to accelerate the deployment of **grid-connected rooftop solar installations**.
- The concept of OSOWOG intends to tap the global solar energy potential for the benefit of all nations and requires an **international electricity grid to allow inter-country free flow of power.**
- To achieve this, the OSOWOG will require certain changes in the regulatory framework, especially in two areas:
  1. Grid security for the Indian grid.
  2. Development of appropriate international energy exchange.

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- The grid has to be a **"smart grid"** in order to obtain highest efficiencies given the constraints of transmission of solar power, **i.e., transmission losses**.
- OSOWOG is planned to be completed in **three phases**.
  1. The first phase will entail interconnectivity within the Asian continent;
  2. The second phase will add Africa and
  3. The third phase will globalize the whole project.
- OSOWOG is seen as **India's counter to China's Belt and Road initiative (BRI)**. India and Solar Energy

34.3. Steps taken by India to increase the share of Solar Energy

- Globally **India now ranks 4th in terms of Renewable power**.
- The Indian government has implemented a scheme named **KUSUM** that aims to **replace the use of diesel in our farm sector with solar energy**.
  - ✓ Under this scheme, India have targeted the solarisation of 2.8 million irrigation pumps.
  - ✓ Such schemes will not only benefit the environment but also increase the income of our farmers.
- India has also set up a **Project Preparation Facility** to develop **bankable Solar Energy projects** in ISA member countries with the help of **EXIM Bank of India**.

Q. Describe the benefits of deriving electric energy from sunlight in contrast to the conventional energy generation. What are the initiatives offered by our Government for this purpose? (UPSC CSE Mains 2020 – 250 words).

34.3.2. PM-KUSUM Scheme

- PM-KUSUM: **Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan**
- It was launched in 2019 by the **Ministry of New and Renewable Energy (MNRE)** to support
  - ✓ Installation of **off-grid solar pumps in rural areas** and
  - ✓ **Reduce dependence on grid, in grid-connected areas**.
- PM-KUSUSM scheme consists of three components:
  1. **10 GW of Decentralized Ground Mounted Grid Connected Renewable Power Plants.**
  2. **Installation of 17.50 lakh standalone (off grid) Solar Powered Agriculture Pumps.**
  3. **Solarisation of 10 Lakh Grid-connected Solar Powered Agriculture Pumps.**
- All three components combined, PM-Kusum aims to add a solar capacity of **25.75 GW by 2022**.
- The total central financial support provided under the scheme would be Rs. 34,422 crores.
- Besides reducing emissions, the scheme aims to address challenges of irrigation supply, subsidy burden on discoms (~Rs 50,000 crores) and farmer income (sale of surplus power).

Expected benefits of the PM-KUSUM Scheme

- It reduces farmers' dependence on diesel and kerosene.
- It enables the farmers to set up solar power generation capacity and sell it to the grid.
- It enables farmers would be able to earn a livelihood through their baron land also.
- Besides reducing emissions, the scheme also reduces the subsidy burden on discoms (~Rs 50,000 crores).

Criticism of PM-KUSUM Scheme

- The scheme might result in over-exploitation of groundwater.
- PM-KUSUM may also not help reduce discoms' subsidy burden because the installation of pumps is not mandatorily tied to decrease in subsidized agricultural power supply.

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- PM-KUSUM proposed scheme of installing solar plants on farmland might benefit only the wealthy farmers, as it requires large investment or the ability to lease land for 25 years.

Union Budget 2020 sets new targets

- The scheme is now extended to
  1. **Setup 20 lakh standalone solar pumps (earlier it was 17.5 lakhs)**.
  2. **Solarisation of 15 Lakh Grid-connected Solar Pumps (earlier it was 10 lakh).**
- The scheme will also allow farmers to set up grid-connected solar power generation on barren land.

34.3.3. Rooftop Solar (RTS) Programme

- The MNRE had, in 2015, approved a programme '**grid connected rooftop and small solar power plants programme**', which aimed to install **4,200 MW (42. GW)** rooftop solar plants by year 2019-20.
- But, in the first phase **only 2,158 megawatts (MW)** of rooftop solar (RTS) systems could be installed.
- **Ministry of New and Renewable Energy (MNRE)** issued guidelines to implement the second phase of grid-connected rooftop solar photovoltaic programme.
- Under the second phase, **22 GW** of rooftop solar PV projects must be set up.
- **Karnataka** ranked the best for setting up a rooftop solar (RTS) project, according to the state rooftop solar attractiveness index (SARAL) released by the Centre.
- **Telangana, Gujarat** and **Andhra Pradesh** scored a rating of A++, while J&K was placed at the bottom.
- In the second phase, the electricity distribution companies (discoms) will play a key role in expansion of RTS.
- This is to ease the consumer's challenge of approaching multiple agencies for getting an RTS plant installed.

34.3.4. National Programme on Solar PV Modules

- The cabinet approved a **production linked incentive (PLI) scheme** with an outlay of Rs 4,500 crore **to add 10,000MW capacity of integrated solar PV modules manufacturing plants.**
- Solar capacity addition presently depends largely upon **imported solar PV cells** & modules.

Expected Benefits

- **Additional 10,000 MW** capacity of integrated solar PV manufacturing plants.
- **Direct investment** of around Rs.17, 200 crore in solar PV manufacturing projects.
- **Increased Demand** of Rs.17, 500 crore over 5 years for 'Balance of Materials'.
- **Direct employment** of about 30,000&indirect employment of about 1, 20,000 persons.
- Import substitution of around Rs.17, 500 crore every year **(Reduce imports in sectors like fuel)**.
- **Impetus to Research & Development** to achieve higher efficiency in solar PV modules.
- It will support the Atmanirbhar Bharat initiative.

34.3.5. National Wind-Solar Hybrid Policy

- **MNRE** released a **solar-wind hybrid policy in 2018.**
- The Policy seeks to promote new hybrid projects as well as **hybridization of existing wind/solar projects.**
- The Policy provides for:
  - ✓ Integration of wind and solar at AC as well as DC level.
  - ✓ Flexibility in share of wind and solar components in hybrid projects.
  - ✓ Procurement of power from a hybrid project on tariff based transparent bidding process.

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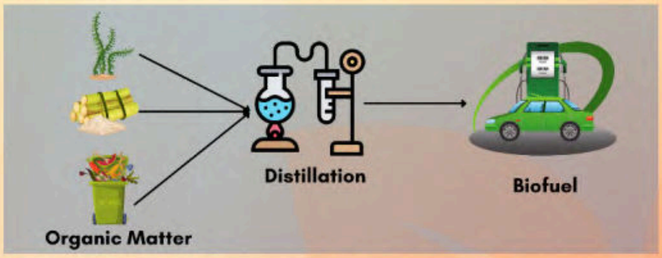
BIOFUEL

What is Biofuel?

- Any hydrocarbon fuel i.e. Solid, Liquid or Gas, that is produced from an organic matter which may be living or once living material, in a short period of time is considered a biofuel.
- Biofuels emit less carbon dioxide (CO_2) than conventional fuels they can be blended with existing fuels as an effective way of reducing CO_2 emissions in the transport sector.



Examples

- **Solid:** Wood, Manure
- **Liquid:** Bioethanol and Biodiesel
- **Gaseous:** Biogas

Generations of Biofuel

1st Generation Biofuel

- Produced directly from food crops
- It has High Carbon Content.
- Made from Edible Items. Eg- Sugar, Corn. Starch etc.
- These biofuels can produce Negative Net energy gains.

2nd Generation Biofuel

- Produced from non-food crops.
- Eg- Rice Husk, Wood Chips etc.
- Greenhouse Gas content less than 1st Generation Biofuel.

3rd Generation Biofuel

- Produced from specially engineered energy crops such as algae.
- It is Carbon Neutral (CO_2 Emitted = CO_2 Sequestrated)

4th Generation Biofuel

- Made from 'Genetically Engineered Crops'.
- They are Carbon Negative.
- They are aimed at not only producing sustainable energy but also a way of capturing and storing CO_2.
- It also reduces CO_2 emissions by replacing fossil fuels.

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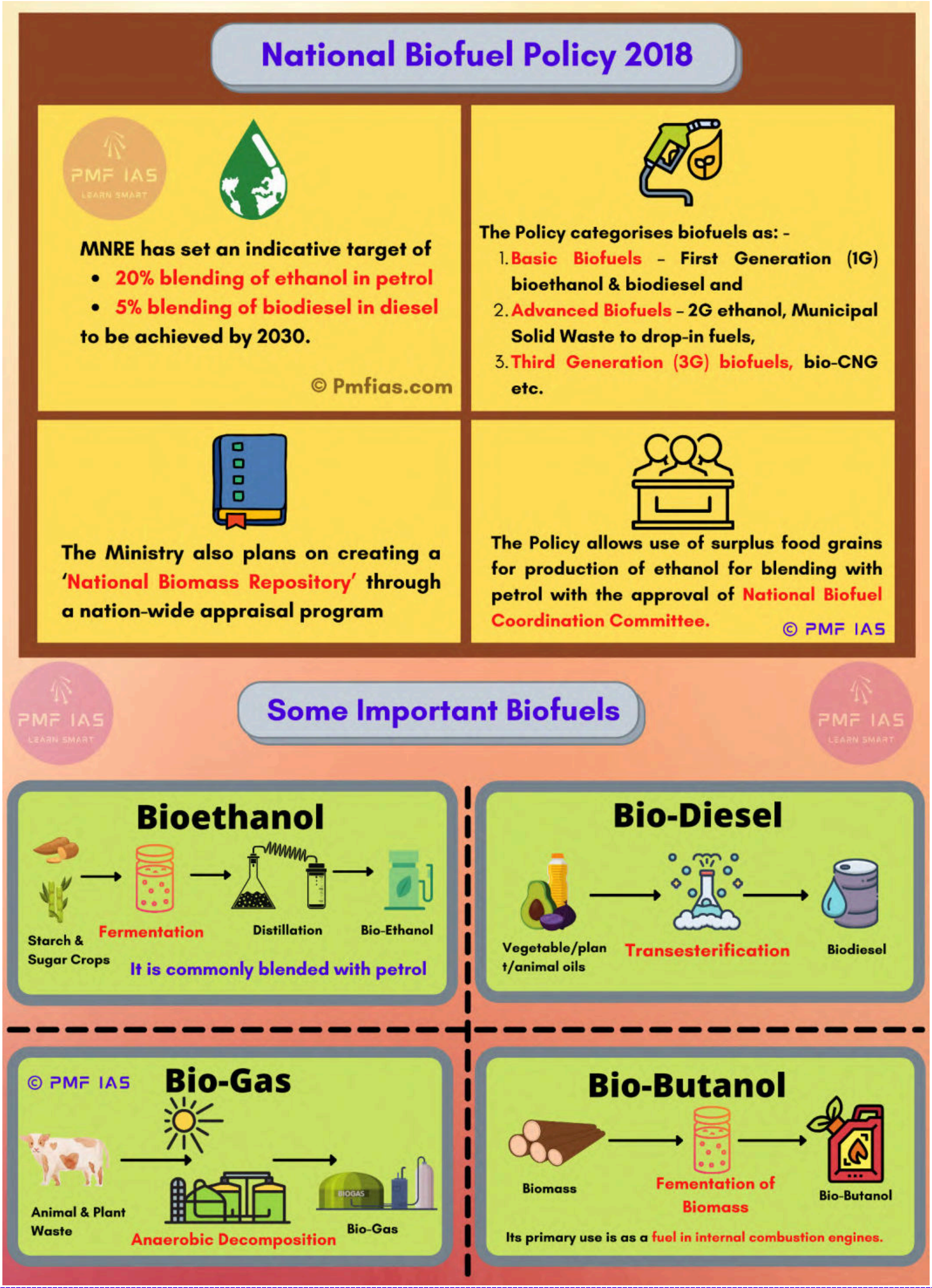

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- For a project to be recognized as hybrid project, rated power capacity of one resource should be at least 25% of the rated power capacity of other resource.
- The objective of the policy is to provide a framework for promotion of large grid connected wind-solar hybrid system for **efficient utilization of transmission infrastructure and land**.
- It also aims at **reducing the variability in renewable power generation** and achieving better grid stability.

MoEF relaxed the lease norms for wind power projects

- Currently, to establish wind power project over forest land, the existing procedure requires payment of **mandatory charges for compensatory afforestation and Net Present value (NPV)**.
- In addition to these charges, the companies had to pay additional lease rent of Rs. 30,000/- per MW.
- **MoEF has now relaxed the mandatory charging** of lease rent of Rs. 30,000/- per MW for wind power projects. It is expected that this step will **boost the investment in wind power projects** & make it cheaper.

34.4. Biofuel

- **Any hydrocarbon fuel** i.e., solid, liquid or gas, that is **produced from an organic matter** which may be living or once living material, **in a short period of time** is considered a biofuel.
- Examples of biofuels include:
  - ✓ Solid: Wood, manure
  - ✓ Liquid: **Bioethanol** and **Biodiesel**
  - ✓ Gaseous: **Biogas**
- As **biofuels emit less carbon dioxide (CO_2) than conventional fuels** they can be **blended with existing fuels** as an effective way of reducing CO_2 emissions in the **transport sector**.
- Biofuels represent around 3% of road transport fuels in use around the world.

34.4.1. Generations of Biofuel

First Generation Biofuels

- The First Generation biofuels are **produced directly from food crops** by abstracting the oils for use in **biodiesel or producing bioethanol** through conventional methods like **fermentation**.
- Crops such as **wheat and sugar** are the most widely used feedstock for **bioethanol** while **rapeseed oil** has proved a highly effective crop for use in **biodiesel**.
- First generation biofuels have a number of associated problems:
  - ✓ These biofuels can produce **Negative Net energy gains**, **releasing more carbon** in their production than their feedstock's capture in their growth.
  - ✓ The most contentious issue with first generation biofuels is '**fuel vs food**'.
  - ✓ **Biofuels from foodgrains** has been blamed for the **increase in food prices** over the last couple of years.

Second Generation Biofuels

- The Second Generation biofuels are produced from **non-food crops** such as **wood, organic waste, food crop waste &specific biomass crops**, therefore eliminating the main problem with first generation biofuels.
- Second Generation biofuels are also aimed at being **more cost competitive** in relation to existing fossil fuel.
- Life cycle assessments of second-generation biofuels have also indicated that they will increase **Positive net energy gains**, overcoming another of the main limitations of first-generation biofuels.

Third Generation Biofuels

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- The Third Generation of biofuels takes advantage of **specially engineered energy crops such as algae**.
- The algae are cultured to act as a **low-cost, high-energy, and entirely renewable feedstock**.
- It is predicted that algae will have the potential to produce **more energy per acre than conventional crops**.
- Algae can also be grown using land and water unsuitable for food production.
- A further benefit of algae-based biofuels is that the fuel can be manufactured into a **wide range of fuels such as diesel, petrol, and jet fuel**.
- **It is potentially carbon neutral (the same amount of carbon is absorbed and emitted)**.

Fourth Generation Biofuel

- The Fourth Generation biofuels are aimed at not only producing sustainable energy but also a way of **capturing and storing CO_2**.
- Biomass materials, which have absorbed CO_2 while growing, are converted into fuel using the **same processes as second-generation biofuels**.
- This process differs from second and third generation production as at all stages of production the **carbon dioxide is captured using processes such as oxy-fuel combustion**.
- The carbon dioxide can then be **geo-sequestered** by storing it in old oil and gas fields or saline aquifers. This carbon capture makes 4th generation biofuel production **carbon negative** rather than simply carbon neutral, as it is locks away more carbon than it produces.
- This system not only captures and stores carbon dioxide from the atmosphere, but it also **reduces CO_2 emissions by replacing fossil fuels**.

34.4.2. Advantages of Biofuels

Increases life of Vehicle Engine

- Biofuels are adaptable to current engine designs and perform very well in most conditions.
- They have **higher cetane** & **better lubricating properties**. This keeps the engine running for longer, requires less maintenance and brings down overall pollution.

Less Carbon Emissions

- Biofuel is made from renewable resources and relatively less-flammable compared to fossil diesel.
- Biofuel causes less harmful carbon emissions compared to standard diesel.
- Studies suggest that biofuels **reduce greenhouse gases by up to 65 per cent**.

Easy to Source

- Biofuels are made from many different renewable sources such as manure, waste from crops, corn, switchgrass, soy-beans, algae and plants grown specifically for the fuel.

Economic Security

- If more people start shifting towards biofuels, a country can reduce its dependence on fossil fuels.
- Fuelling homes, businesses and vehicles with biofuels are less expensive than fossil fuels.
- More jobs will be created with a growing biofuel industry, which will keep our economy secure.

Lower Levels of Pollution

- Biofuels are biodegradable that reduces the possibility of soil contamination and contamination of underground wa-ter during transportation, storage or use.

Cost-Benefit

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- As of now, biofuels cost the same in the market as gasoline does.
- However, the overall cost-benefit of using them is much higher.
- They are cleaner fuels, which means they produce fewer emissions on burning.
- With the increased demand, they have the potential of becoming cheaper in the future as well.

34.4.3. Disadvantages of Biofuels

High Cost of Production and Future Price

- High Cost of Production: Biofuels are quite expensive to produce in the current market. The interest and capital investment being put into biofuel production is fairly low.
- Constantly rising prices may make the use of biofuels as harsh on the economy as the rising gas prices are doing right now.

Industrial Pollution

- The carbon footprint of biofuels is less than the traditional forms of fuel when burnt.
- However, the process with which they are produced makes up for that.
- Large scale industries meant for churning out biofuel are known to emit large amounts of emissions and cause small scale water pollution as well.
- Unless more efficient means of production are put into place, the overall carbon emission does not get a very big dent in it. It also causes an increase in NOx.

Changes in Land Use and Pollution

- Biofuel production can encourage monoculture.
- If the land is used to grow a biofuel feedstock, it has to be cleared of native vegetation, which then leads to ecological damage done in three ways.
  - ✓ **First,** the damage is caused by destroying local habitant and reduces the overall health of natural resources of the region.
  - ✓ The native forest is almost always better at removing CO_2 from the atmosphere than a biofuel feedstock partly because the CO2 remains trapped and is never released by burning as with fuel stock.
  - ✓ **Secondly,** the damage is done in the **carbon debt** created.
  - ✓ Estimates have shown that deforesting native land can actually produce a carbon debt that can take up to 500 years to repay.
  - ✓ Finally, changing land to an agricultural status almost always means fertilizers are going to be used to get the most yields per area. The problem is runoff and other agricultural pollution.
- Thus, creating more farmland is likely to damage waterways and energy used in treatment plants, and other mitigation strategies lead to an even larger carbon debt.

Biofuel is less suitable for use in low temperatures

- It is more likely to attract moisture than fossil diesel, which creates problems in cold weather.
- It also increases microbial growth in the engine that clogs the engine filters.

34.5. Evolution of Indian Biofuels

1975	• India begins examining the feasibility of blending ethanol with petrol.
2002	• The government **mandates the blending of 5% ethanol in some states**.
2004	• Problems related to the feedstock supply of molasses force the Indian government to suspend mandatory blending of ethanol in petrol.

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2005	• The resurgence in sugar and molasses production results in renewed interest in ethanol programme. • The government fixes purchase price of ethanol by oil companies at Rs 18.25 per litre.
2006	• The government announces a Biodiesel Purchase Policy, fixing the purchase price for oil companies at Rs 25 per litre. • Initially, **5% biodiesel is blended with diesel**, with plans to **extend the blending to 20%**.
2007	• A Biofuels Mission focusing specifically on **pongamia** and **jatropha** is also launched.
2009	• National Biofuel Policy 2009 launched.
2018	• National Biofuel Policy 2018 Launched.

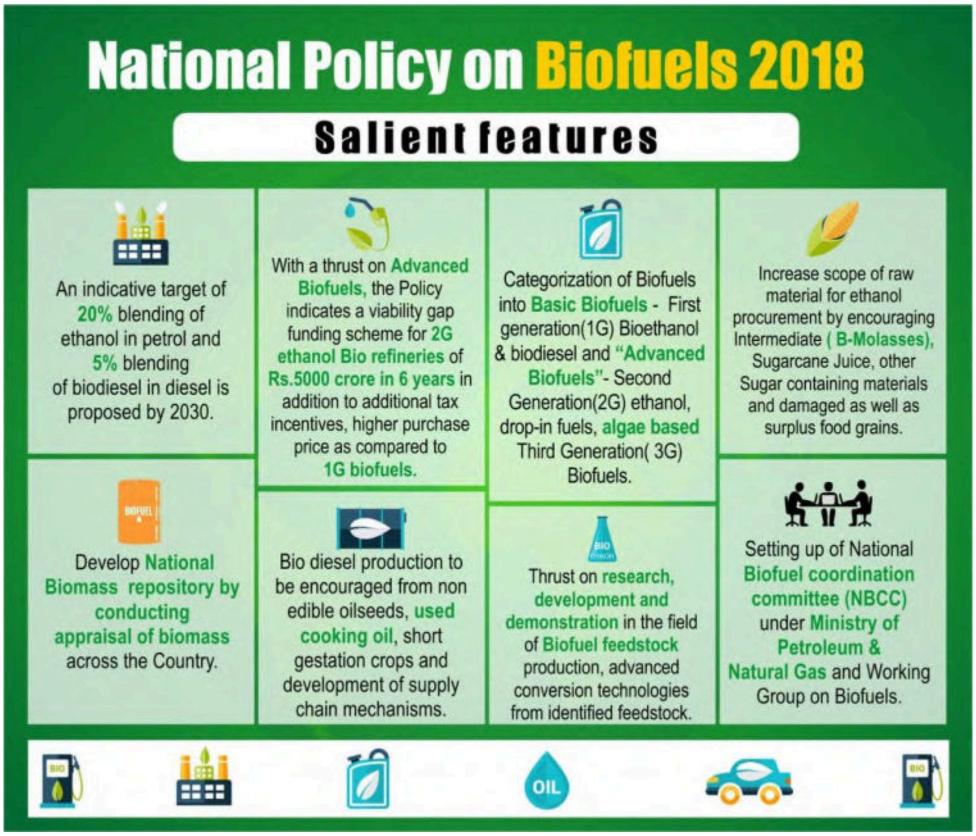
34.5.1. National Policy on Biofuels 2018

- National Policy on Biofuel 2018 is a revised version of National Policy on Biofuels made by **Ministry of New and Renewable Energy** during the year 2009.

The Highlights of the Policy are

1. MNRE has set an indicative target of **20% blending of ethanol in petrol** and **5% blending of biodiesel in diesel to be achieved by 2030**. (The percentage of the same currently stands at around **2% for petrol and less than 0.1% for diesel**).
2. The Policy categorizes biofuels as: -
   1. **Basic Biofuels – First Generation (1G) bioethanol & biodiesel and**
   2. **Advanced Biofuels – Second Generation (2G) ethanol, Municipal Solid Waste to drop-in fuels,**
   3. **Third Generation (3G) biofuels, bio-CNG etc.**

- The Policy expands the scope of raw material for ethanol production by allowing use of-
  - ✓ **Sugarcane Juice, Sugar containing materials like Sugar Beet, Sweet Sorghum, Starch containing materials like Corn, Cassava, etc**.
  - ✓ **Damaged food grains** like wheat, broken rice, Rotten Potatoes, unfit for human consumption.
  - ✓ **Surplus food grains** with the approval of National Biofuel Coordination Committee.



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Q. According to India's National Policy on Biofuels, which of the following can be used as raw materials for the production of biofuels?

1) Cassava
2) Damaged wheat grains
3) Groundnut seeds
4) Horse gram
5) Rotten potatoes
6) Sugar beet

Select the correct answer using the code given below:

a) 1, 2, 5 and 6 only
b) 1, 3, 4 and 6 only
c) 2, 3, 4 and 5 only
d) 1, 2, 3, 4, 5 and 6

Answer: a) 1, 2, 5 and 6 only

- The use of damaged food grains and surplus food grains for the production of ethanol will increase its availability for **Ethanol Blended Petrol (EBP) Programme**.
- **Bioethanol:** Fuels produced from materials that have
  - ✓ **sugar** such as sugar cane, sugar beet, sweet sorghum, etc.;
  - ✓ materials that have **starch** such as corn, cassava, rotten potatoes, algae, etc.;
  - ✓ **cellulosic materials** such as bagasse, waste wood, agricultural/forestry residues, etc. or other renewable industrial waste fall in this category.
- **Biodiesel:** This category includes methyl or ethyl ester of fatty acids derived from **non-edible vegetable oil**, **acid oil, used cooking oil, animal fat and bio-oil**.
- **Advanced biofuels:** Second-generation (2G) ethanol, drop-in fuels, algae-based 3G biofuels, bio-CNG, **bio-methanol, dimethyl ether (DME)**derived from **bio-methanol, bio-hydrogen**, drop-in fuels produced from municipal solid waste (MSW), etc. have been included in this category.
- **Drop-in fuels:** These are fuels derived from biomass, Agri-residues, MSW, plastic wastes, etc., that can be used in existing engines without having to modify their fuel distribution system.
- **Bio-CNG:** These fuels are purified form of biogas produced from agricultural residues, dung, food waste, sewage water but their composition and energy potential are comparable to fossil-based natural gas.

3. The Policy allows **use of surplus food grains for production of ethanol** for blending with petrol with the approval of **National Biofuel Coordination Committee**.

Ethanol Blended Petrol (EBP) Programme

- The National Policy on Biofuels-2018 approved by the Government envisages an indicative target of **20% blending of ethanol in petrol** and **5% blending of biodiesel in diesel by 2030**.
- Under EBP programme, ethanol blending in petrol is being undertaken by the Oil Marketing Companies.

E20 Fuel

- **E20 fuel is a blend of 20% of ethanol with gasoline,** as an automotive fuel and for the adoption of mass emission standards for this fuel.
- The **current permissible level of blending is 10% of ethanol**.

34.6. Some Important Biofuels

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34.6.1. Bioethanol

- Bioethanol (aka **ethanolor ethyl alcohol (C_2H_5OH)**) is an **alcohol** produced from **starch and sugar crops**.
- Bioethanol is mainly produced by **fermentation** and by **reacting ethylene with steam**.
- **Ethanol** is a **clear, colourless liquid**.
- It is biodegradable, low in toxicity and causes little environmental pollution.
- Ethanol burns to produce carbon dioxide and **water**.
- Ethanol is a high-octane fuel and has replaced lead as an **octane enhancer in petrol**.
- By blending ethanol with gasoline, we can also **oxygenate the fuel mixture, so it burns more completely** and reduces polluting emissions.

34.6.2. Biobutanol

- Biobutanol is **four-carbon alcohol** produced by the fermentation of biomass.
- The production of biobutanol can be carried out in ethanol production facilities.
- Its properties are similar to that of **gasoline**.
- Some gasoline-powered vehicles can even use biobutanol **without being modified**.
- However, it has a **lower energy content, on average 10-20%, than that of gasoline**, which is a major disadvantage of biobutanol.
- Biobutanol exhibits the potential to **reduce carbon emissions** by 85% when compared to gasoline, thus making it a viable and suitable alternative to gasoline and gasoline-ethanol blended fuels.

34.6.3. Biodiesel

- Biodiesel is made from **renewable sources** such as **vegetable/plant/animal oils** for use in diesel engines.
- Vegetable oils are chemically called triglycerides (fats).
- Biodiesel comprises esters of long chain fatty acids derived from these oils.
- To make biodiesel, fats in the vegetable oil (triglycerides) are reacted with **alcohol** — usually **methanol**.
- In this reaction, glycerine (in triglycerides) is replaced by methanol to produce **methyl ester (biodiesel)**.
- Biofuel development in India centres around the cultivation of **Jatropha plant seeds** — rich in oil (40%).
- In 2008, the Indian Government announced its **'National Biofuel Policy'**.
- It aims to meet 20% of India's diesel demand with fuel derived from plants.

Biodiesel blend

- The biodiesel blend is a mix of biodiesel with fossil fuel, designated as BXX, where XX represents the volume percentage of biodiesel in the blend (**B100 means pure biofuel**).
- Currently, biodiesel is blended with the fossil fuel in the proportion of 2%, 5%, etc, although technically it can be used as a pure fuel with some minor modifications in existing engine systems.
- The blend ratio is based more on the available quantity of biodiesel rather than technical reasons.
- Filling stations in the European Union countries and the United States supply everything from B2 to B100.
- **Except B100**, these blends can be **used in any existing diesel engine without any modifications**.

Advantages of Biodiesel

- Biodiesel has **intrinsic lubricating properties (diesel engines are long lasting compared to petrol engines because of this very property)** due to the presence of long chain fatty acids.
- The **Cetane Index (CI)**, a measure of the inflammability of fuel, is more than 56 to 58 for biodiesel compared 50/52 for fossil fuel. A higher CI value will mean **better ignition and combustion**.

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- The biodiesel molecule contains about 11% oxygen, facilitating improved combustion and **less soot**.
- The **sulphur content in biodiesel is as low** as 0.001%.
- As its viscosity is similar to fossil fuel, no changes are required **in the existing fuel injection equipment**.
- It is **less toxic** and biodegradable.
- It is much safer to handle due to its **high flash point** — more than 130 °C compared to 51 °C for diesel.
- Biodiesel requires **less energy to produce** than fossil fuels (for every unit of energy needed to produce biodiesel, 3.24 units of energy are gained) (each litre of biodiesel saves 2.2 kg greenhouse gases).
- Biodiesel production does not hurt the production of edible oil ('food or fuel' dilemma doesn't exist).

Advantages over other alternative fuels (CNG, LNG, LPG and ethanol)

- Unlike alternative fuels such as CNG, LNG, LPG, and ethanol, biodiesel is both **renewable and sustainable**.
- Unlike other alternative fuels, biodiesel doesn't require significant modifications in existing infrastructure.
- CNG, LNG, LPG, etc. (**low energy content per volume** = frequent refuelling) require bigger storage space.
- Ethanol manufactured from molasses is renewable, but its calorific value is less than that of biodiesel.
- Switching to biodiesel would be **far smoother and cheaper**.
- Abundant availability of fallow land and labour, favourable weather conditions, availability of a wide range of oilseed crops such as soybean, neem, mohwa, jatropha, castor, kusum palash and karanjia.

Biodiesel from (Used Cooking Oil) UCO

- Used Cooking Oil-based Biodiesel under the '**Randhan se Indhan** **(from cooking to fuelling)'scheme** was flagged off recently.

Harmful effects of UCO

- Repeated use & frying leads to the formation of **TPC (Total Polar Compound).**
- It increases **Trans-Fats** & gives rise to free radicals.
- It chokes & clogs municipal sewers & drastically **reduces the efficiency** of the **Wastewater Treatment Plants.**
- It **raises chemical oxygen demand** in water body & severely harms the aquatic & marine life.
- It **harms the marine fauna** by coating them with oily layers, literally reducing their ability to breathe, thus, **choking them to death**.

34.6.4. Biogas

- Biogas is primarily **methane (CH_4) (50–65%)** & **carbon dioxide (CO_2) (35–50%)**.
- Biogas is produced through a process of **anaerobic decomposition** (anaerobic digestion) from biomass.
- Anaerobic digestion uses the process of **fermentation** to breakdown organic matter.
- Fermentation is the chemical breakdown of a substance by bacteria, yeasts, or other microorganisms, typically involving effervescence (bubbles in liquid) and the giving off of heat.
- Biomass sources include agriculture residue, cattle dung, sugarcane press mud, municipal waste, etc.
- After purification, it is compressed & called **CBG (pure methane content of over 95%)**.
- **CBG (calorific value ~52,000 KJ/kg) is similar to CNG** in its composition & energy potential.
- Biogas production is **carbon–neutral; there is no net addition of carbon to the environment** (the carbon in biogas comes from plant matter that fixed this carbon from atmospheric CO_2).
- Challenges: Lack of biowaste segregation & collection at the household level.

SATAT Initiatives

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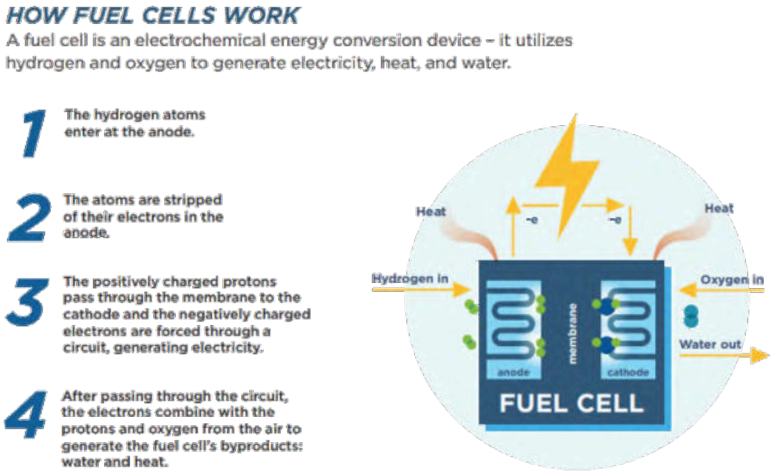
- **Sustainable Alternative Towards Affordable Transportation (SATAT) Initiative** promotes **Compressed Biogas (CBG)** as an alternative, green transport fuel for efficient management of biomass & organic waste.
- **Compressed Biogas plants** are proposed to be set up mainly through independent entrepreneurs.
- SATAT initiative has the potential of addressing environmental problems arising from stubble burning.

34.7. Hydrogen Economy

- **Hydrogen Economy** is the vision of using **hydrogen as a low-carbon energy source**.
- Hydrogen is the **most abundant chemical substance** in the universe.
- It is **not found in pure form on earth.**
- It must be produced from other compounds such as **natural gas, biomass, alcohol, or water**.
- At standard temperature & pressure, hydrogen is a **nontoxic, nonmetallic, odourless, tasteless, colourless, & highly combustible diatomic gas with the molecular formula H_2.**
- There are 3 types of hydrogen – grey, blue & green.
  1. The fuel **produced from fossil fuels** is called **grey hydrogen**.
  2. Fuel produced from fossil fuels with **carbon capture & storage** options are called **blue hydrogen**.
  3. Those produced from **renewable power sources** are called **green hydrogen**.

34.7.1. How Hydrogen Fuel Cells Work?

- **Hydrogen is an energy carrier, not a source of energy**.
- The energy used to produce it usually comes from a more conventional source.
- Hydrogen fuel **must be transformed into electricity** by a device called a **fuel cell stack** before it can be used to power a car or truck.
- **A fuel cell converts chemical energy into electrical energy using oxidizing agents through an oxidation-reduction reaction**.
- Inside each individual fuel cell, hydrogen is drawn from an onboard pressurized tank&**made to react with a catalyst**, usually made from **platinum or palladium or gold** (**used to speed up the reaction**).
- At the anode, a **catalyst** causes hydrogen to undergo **oxidation** & generates **+ve charged ions** & **electrons**.
- The ions move from the anode to the cathode and at the same time, the **electrons flow from the anode to the cathode through an external circuit**, producing direct current **electricity**.
- At the cathode, another catalyst causes ions, electrons, and oxygen to react, forming **water as a by-product**.
- **Hydrogen** and **phosphoric acid** are the most common type of fuel cells, although fuel cells that run on **methanol, ethanol,** and **natural gas** are also available.



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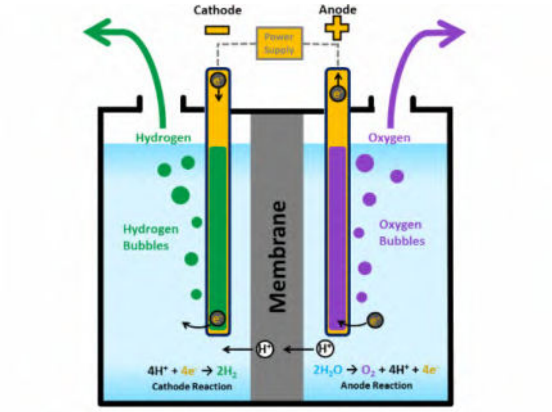
34.7.2. Advantages of Hydrogen as Fuel

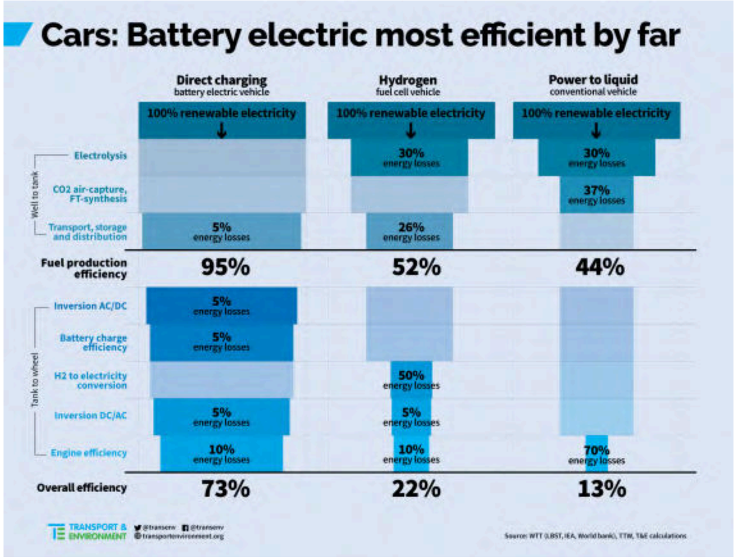
- Fuel cells are more efficient than thermal power plants (thermal energy → mechanical energy → electrical energy➔ less efficient due to loss of energy in the form of heat) as there is a **direct conversion of chemical energy into electrical energy**.
- Hydrogen fuel is abundantly available.
- It is **renewable & non-polluting** (only by-product hydrogen fuel cell leaves is **water)**.
- Compared to diesel or gas, $H_2$is **more fuel-efficient** as it can produce more energy per pound of fuel.
- It can be **produced from a wide variety of resources** & can be used in a wide range of applications, such as power generation, as a transport fuel for low carbon vehicles, etc.

34.7.3. Disadvantages of Hydrogen as Fuel (Hydrogen is clean but its production is not)

- Fuel cells are costly to produce (**platinum, palladium catalysts are expensive**).
- It is challenging to transport & store hydrogen.
- A **relative lack of off-the-shelf engine technology** that can currently run safely on hydrogen.
- Safety concerns due to the **high reactivity of hydrogen fuel with environmental oxygen**.



- Hydrogen has to be produced from either water or organic compounds like **methane** through **electrolysis (energy-intensive ➔ high carbon footprint)**.
- **Lack of efficient photochemical water-splitting technology**.
- Lack of fuelling station infrastructure (hydrogen vehicle economy is not promising).
- **Electric vehicles are overall a lot more efficient than hydrogen-powered vehicles**.



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⇨ **In the Decreasing order of overall efficiency: EVs > Hydrogen > Diesel > Petrol vehicles**

34.7.4. Current Status of Hydrogen Economy in India

- Hydrogen is **used extensively in India**, mainly as an **industrial feedstock** in the creation of **ammonia-based fertilizers**.
- Most H_2 in India is produced through reforming **methane (CH4)**, resulting in significant **CO_2 emissions**.
- **National Hydrogen Energy Road Map (NHERM**): It was adopted by the **National Hydrogen Energy Board in 2006** for implementation.
- The main objective of NHERM was to identify the pathways, which will lead to the **gradual introduction of hydrogen energy** & **facilitate the creation of hydrogen energy infrastructure** in the country.
- The **Union Budget for 2021-22** has announced a **National Hydrogen Energy Mission (NHM)** that will draw up a **road map for using hydrogen as an energy source**.
- **Delhi** became the **first city in India** to operate buses with **hydrogen-enriched CNG (HCNG).**
- For the current financial year, **MNRE has been allotted Rs 25 crore (!)** for R&D in hydrogen.
- Road & Transport Ministry last year issued a notification proposing amendments to the Central Motor Vehicles Rules, 1989, to **include safety evaluation standards for hydrogen fuel cell-based vehicles**.

Hydrogen-enriched compressed natural gas (HCNG)

- **H-CNG** is a mixture of **compressed natural gas and 4–9 per cent hydrogen** by energy.
- Blending increases the H/C ratio of the fuel and gives it a flame speed up to eight times higher than CNG.
- **Ministry of Road Transport** has allowed the use of **H-CNG (18% blending of H_2 with CNG)** in CNG engines.
- Central Motor Vehicles Rules 1989 were amended for the inclusion of H-CNG as an automotive fuel.
- HCNG **reduces hydrocarbon emissions** and **emissions of CO up to 70%**.
- Engines can be calibrated to **release lower amounts of NO**.
- It is an ideal fuel for high load applications and heavy-duty vehicles. It enables up to 5 % savings in fuel.
- It leads to better performance due to **higher Octane rating of H_2**.

Q. In the context of the proposals to the use of hydrogen-enriched CNG (H-CNG) as fuel for buses in public transport, consider the following statements

1) The main advantage of the use of H-CNG is the elimination of carbon monoxide emissions.
2) H-CNG as fuel reduces carbon dioxide and hydrocarbon emissions.
3) Hydrogen up to one-fifth by volume can be blended with CNG as fuel for buses.
4) H-CNG makes the fuel less expensive than CNG.

Which of the statements given above is/are correct?

a) 1 only
b) 2 and 3 only
c) 4 only
d) 1, 2, 3 and 4

Explanation:

- **H-CNG reduces CO emissions. It does not eliminate it completely.**

Answer: b) 2 and 3 only

34.8. Cleaner Fuels

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- Cleaner fuels are fuels whose emissions are relatively lower than the most widely used fuels like coal, petrol and diesel.

34.8.1. Methanol

- Methanol and ethanol can be produced form **coal, petroleum, natural gas** and **biomass waste**.
- Methanol is currently produced by breaking down **natural gas (methane)** at high pressure and temperatures into **hydrogen gas** and **carbon monoxide** before reassembling them — an expensive process.
- **CO_2** can be converted into **methanol** (treating CO_2 with hydrogen gas (H_2)) or **methane**.
- **Methanol economy will help India use its vast reserves of coal (burning coal directly is bad)**.

Methanol	Ethanol
• Methyl Alcohol (CH_3OH)	• Ethyl Alcohol (**drinking alcohol**) (CH_3-CH_2-OH)
• Methanol is toxic and hence it is **not suitable for consumption**.	• Ethanol is used in alcoholic beverages, as additive in foods, etc.
• Methanol is mostly used to create other chemicals such as **acetic acid** and **formaldehyde**.	• It has antiseptic properties and is found in anti-bacterial wipes and hand gels. • It is also the base of many paints and perfumes because it is a good solvent.
• Its odour is distinctive, and it burns as a bright white flame.	• It has a strong, burning odour and will burn as a bright blue flame.
• Most of the methanol is produced from **coal** and **natural gas**.	• Most of the ethanol is produced by **fermentation of bio-waste and food crops**.
• Volatile, flammable, colourless • They are both used as solvents • Both are **clean fuels** • **Both can be blended with petrol and used as automobile fuel**.	

Advantages of methanol as fuel

- Methanol and ethanol are **relatively cleaner fuel** (low carbon emissions).
- Unit cost of energy produced from methanol is **cheaper** than that from petrol, diesel, LPG, etc.
- Methanol is lighter than petrol and diesel.
- It **burns efficiently** in all internal combustion engines, produces **no particulate matter, no soot, almost nil SOX and NOX emissions**.
- **Methanol 15 % blend (M15)** in petrol will reduce pollution by 33% & diesel replacement by methanol will reduce by more than 80%.
- To adopt Methanol as a transport fuel, it requires **little infrastructure modifications** compared to other alternative fuels such as CNG, LPG, etc.

Methanol Economy

- **Methanol Economy** is the "Bridge" to the dream of a complete "Hydrogen based fuel systems".
- The Concept of "Methanol Economy" is being actively pursued by China (10% of fuel in transport sector).
- NITI Aayog has drawn out a comprehensive plan to **replace 20% of crude imports from Methanol alone**.
- GOI aims to increase **fuel blending** (**methanol, ethanol, or biodiesel**) to **20 per cent by 2030**.

34.8.2. Liquefied Petroleum Gas (LPG)

- LPG consists mainly of **propane, butane, butylene, propylene**, etc. in various mixtures.

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- It is produced as a **by-product of natural gas (mostly methane)** processing and petroleum refining.
- As **LPG is heavier than air**, places with poor ventilation tend to trap the gas in case of leakage.
- LPG is **odourless** in its natural state. **Ethyl Mercaptan** or **Ethanethiol** (reaction of **ethylene** with **hydrogen sulphide**) that has a strong odour is added to LPG to detect leakage.

34.8.3. Liquefied Natural Gas (LNG)

- Liquefied Natural Gas or LNG is natural gas stored as a **super-cooled liquid (cryogenic)** (-120 to -170°C).
- Advantage: takes up less space thereby extending range and reducing refuelling frequency.
- Disadvantage: **high cost** of cryogenic storage, transportation and dispensation.
- LNG is used in heavy-duty applications in developed countries like the US, Japan, etc.
- For many developing nations, using LNG is currently not a practical option.

34.8.4. Compressed Natural Gas (CNG)

- Natural gas is drawn from gas wells or in conjunction with crude oil.
- When natural gas is compressed and stored in tanks it is called Compressed Natural Gas or CNG.
- Natural gas is mostly **methane** and to some extent **ethane** and **propane**.
- Other gases such as nitrogen, **carbon dioxide, sulphur** compounds, etc. are also present.
- A sulphur-based odorant is normally added to CNG to facilitate leak detection.
- Advantage over LPG is that **CNG is lighter than air and thus will quickly dissipate** in the case of a leak.
- CNG is a clean burning fuel, i.e., burning it **leaves little or no residue (reduced engine maintenance)**.
- Although natural gas **produces GHGs**, it is considerably reduced compared to petrol or diesel.
- CNG is **much safer compared to petrol and diesel**. It has a **high auto-ignition temperature**.
- CNG is **cheaper** than petrol and diesel.
- CNG also carries a high calorific value (50,000 kJ/kg) as compared to petrol (45000 kJ/kg).
- Disadvantages: **Large fuel tanks, less range, very few filling stations, old vehicles not designed for CNG**.

34.8.5. Biogas

- Biogas is primarily **methane (CH_4) (50-65%)** and **carbon dioxide (CO_2) (35-50%)**.
- Biogas is produced through a process of **anaerobic decomposition** (anaerobic digestion) from biomass.
- Anaerobic digestion uses the process of **fermentation** to breakdown organic matter.
- Biomass sources include agriculture residue, cattle dung, **sugarcane press mud**, municipal waste, etc.
- After purification, it is compressed and called **CBG (pure methane content of over 95%)**.
- CBG (calorific value ~52,000 KJ/kg) is similar to CNG in its composition and energy potential.
- Given the abundance of biomass in the country, CBG has the potential to replace CNG.
- Biogas production is **carbon-neutral**, i.e., there is no net addition of carbon to the environment (the carbon in biogas comes from plant matter that fixed this carbon from atmospheric CO_2).
- Challenges: **Lack of bio-waste segregation and collection at the household level**.

34.9. Indian Renewable Energy Development Agency (IREDA)

- IREDA is a **Mini Ratna (Category – I) Public Limited Government Company**.
- It is **under** the administrative control of **Ministry of New & Renewable Energy**.
- IREDA is established as a **Non-Banking Financial Institution** in **1987**.

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- It is **engaged in** promoting, developing & extending financial assistance for setting up projects relating to new & renewable sources of energy & energy efficiency/conservation with the motto: **"Energy for Ever".**

Objectives

- To **give financial support** to specific projects & schemes for generating electricity & / or energy through new & renewable sources & conserving energy through energy efficiency.
- To **increase IREDA's share** in the **renewable energy sector** by way of innovative financing.

With reference to the Indian Renewable Energy Development Agency Limited (IREDA), which of the following statements is/are correct?

3) It is a Public Limited Government Company.
4) It is a Non – Banking Financial Company.

Select the correct answer using the code given below.

e) 1 only
f) 2 only
g) Both 1 and 2
h) Neither 1 or 2

Answer: c) Both 1 and 2

34.9.2. Challenges Faced in Renewable Energy Sources

- Wind & solar power have a **lower plant load factor (PLF) than thermal power.** Therefore, renewable capacity addition needs to be higher than for thermal plants to generate the same amount of electricity.
- Renewable energy **relies on intermittent sources** like sun, wind, tides, etc. and hence its **output is constrained to specific hours of the day**. This can create **issues in matching peak power demand**.
- For example, solar output is maximum between 11 am and 3 pm, while wind output is highest in the late evening and early morning. However, peak demand for power is reached in the evening hours of 6-9 pm, which cannot be catered to by either wind or solar.
- Its usage leads to **lower utilization of transmission lines** and hence **relatively increased costs of transmission**.
- The NITI Aayog had observed that electricity buyers in renewable poor states are relatively less willing to purchase renewable electricity due to higher costs than the conventional sources.

Q. India has immense potential of solar energy though there are regional variations in its development. Elaborate. (UPSC CSE Mains 2020 – 250words)

Smart Grid to Address the Challenges

- Smart grid uses digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines for **efficient management** of the distribution system.
- Smart Grid will consist of controls, computers, **automation**, and new technologies and equipment working together with the electrical grid to respond digitally to quickly changing electric demand.
- Smart grids are essential for reliability, availability, and efficiency.
- **National Smart Grid Mission (NSGM):** The Mission was launched in March 2015 and seeks to plan and monitor the implementation of policies and programmes related to Smart Grid.

The benefits associated with the Smart Grid include:

- More efficient transmission of electricity
- Quicker restoration of electricity after power disturbances

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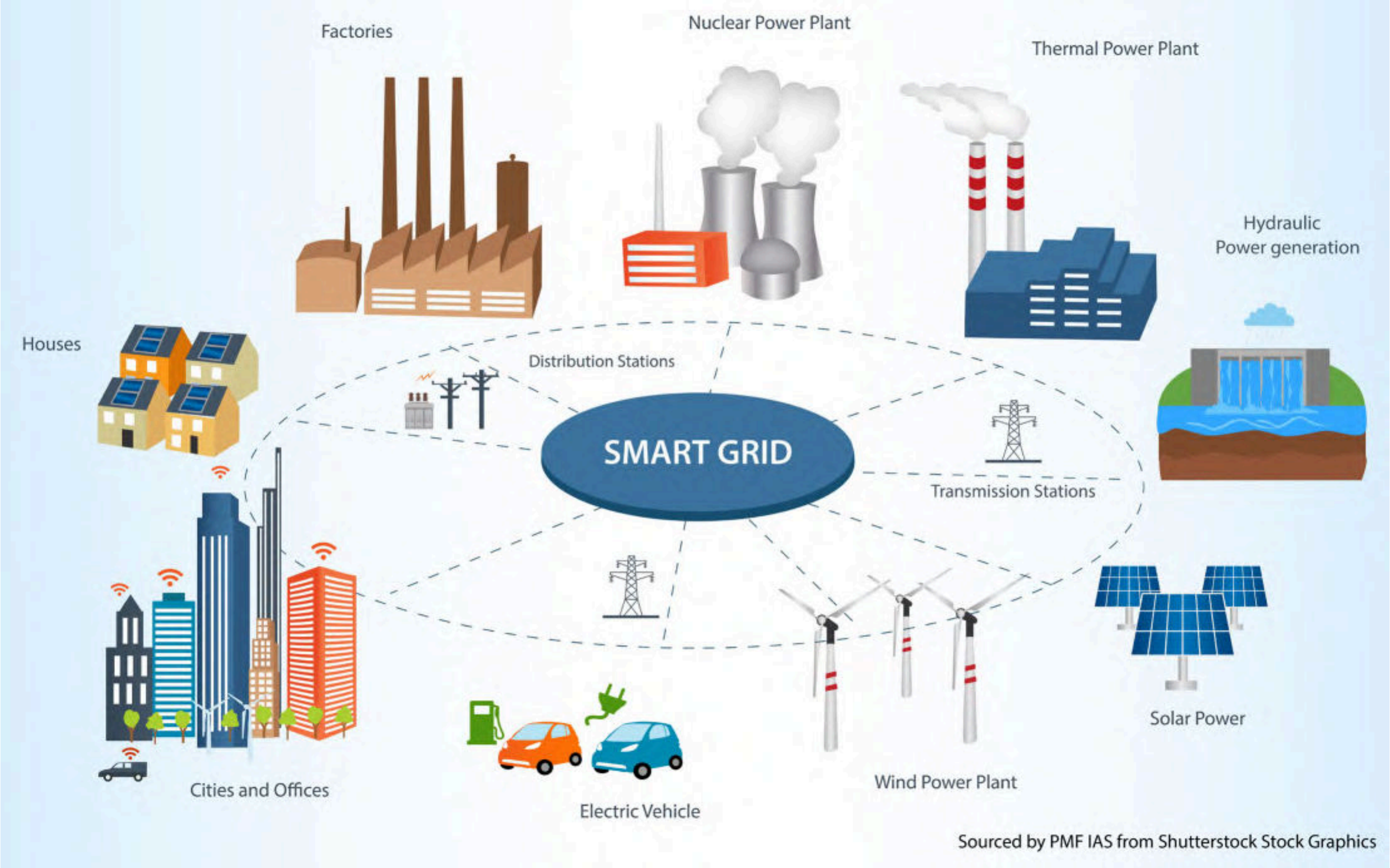
- Reduced peak demand
- **Increased integration of large-scale renewable energy systems**



Hybrid Energy Systems

- To overcome the shortcomings in renewable sources of energy, there is a need to focus on hybrid systems of energy storage and supply to cut down costs and to ensure continuous supply of electricity.

What does hybrid systems constitute?

- Hybrid systems of energy storage and supply include **flexible energy resources** which can **rapidly ramp up or down power supply as needed**.
- These could include hydro or gas-based power or energy storage solutions (**batteries**).

How they work?

- Hybrid systems store excess energy during renewable generation hours and release it into the grid during peak demand hours. In this way, it can provide both baseload and flexible 24x7 clean energy.

The cost advantages

- Hybrid systems are becoming increasingly cost-competitive, driven by reducing costs of battery storage.
- Also, Li-ion battery costs are expected to fall from current $220-240/kWh to below $100 in next 3-4 years.
- Similarly, costs of solar energy have plummeted from ₹4.63/kWh in 2016 to ₹2.50/kWh in the latest auctions.

Can hybrid systems substitute coal-fired power plants?

- The hybrid systems can potentially be competitive with 30-40% of existing coal-fired stations in India.

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35. Water Conservation

- A hundred cities worldwide, including 30 in India, face the risk of **severe water scarcity** by 2050, according to a recent report by **World Wide Fund for Nature (WWF).**
- The cities would face a **'grave water risk'** by 2050 due to a dramatic increase in their population percentage to 51 % by 2050, from 17 % in 2020. The cities include global hubs such as **Beijing, Jakarta, Johannesburg, Istanbul, Hong Kong, Mecca and Rio de Janeiro**.
- Thirty Indian cities are also included in the list.
- **Jaipur topped the list of Indian cities, followed by Indore and Thane.**
- Mumbai, Kolkata, and Delhi are also featured on the list.
- More than **half** of the identified cities are from **China & India.**

35.1. Difference between Water Scarcity, Water stress and Water risk

Water Scarcity	Water Stress	Water Risk
• "Water scarcity" refers to the **volumetric abundance**, or lack thereof, of water supply. • Water scarcity is a physical, objective reality that can be measured consistently across regions and over time.	• "Water stress" refers to the **ability, or lack thereof**, to meet human and ecological demand for water. • Compared to scarcity, "water stress" is a more inclusive and broader concept. • It considers several physical aspects related to water resources, including water scarcity, but also **water quality**, **environmental flows**, and the **accessibility of water**.	• "Water risk" refers to the **probability of an entity experiencing a deleterious water-related event.** • Water risk is **felt differently by every sector of society** and the organizations within them and thus is defined and interpreted differently (even when they experience the same degree of water scarcity or water stress).

- **"Water scarcity"** is one aspect of many that contribute to **"water stress."**
- **An area could be highly water-stressed but not water scarce** if, for example, it had **water pollution** but plentiful supplies of contaminated water.
- **Water scarcity:** there is a lack of adequate availability or supply of water.
- **Water scarce regions:** Rajasthan, Gujarat, rain-shadow region of Western Ghats (Hyderabad-Karnataka, Vidarbha), and other drought-prone regions.
- **Water stress:** it is caused either due to water scarcity or due to the unusable nature of the available water.
- **Water stress regions (spatial pattern of water stress):** All the water-scarce regions plus the regions affected by
  - ✓ Urban and industrial pollution (Ganga-Yamuna industrial region, mining hotbeds like Odisha, Jharkhand and metropolitan cities like Mumbai, Bengaluru),
  - ✓ alkalinity and salinity (overexploited regions like Punjab-Haryana),
  - ✓ marine saline ingress (coastal regions affected by cyclones and storm surge)
  - ✓ marine saline ingress due to sea-level rise (due to climate change)

Q. What is water stress? How and why does it differ regionally in India?

Mains Practise: What is the difference between water scarcity and water stress? Describe the spatial pattern of water stress in

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India.

Water Requirement

- The absolute minimum water requirement for domestic usage is **50 litres per person per day.**
- Ideal requirement = 100-200 litres/person/day.

35.2. India's Water Situation

- India accounts for 16 % of the world's population living in less than 2.5 % of the global area & has **just 4 % of the worldwide water resources**.
- According to the **Central Water Commission (CWC)**, the estimated water resources potential of the country, which occurs as natural runoff in the rivers, is 1,999 billion cubic metres (BCM).
- Of this, the estimated utilizable resources are 1,122 BCM per year — **690 BCM per year surface water** & **432 BCM per year replenishable groundwater**.
- Water-scarcity condition is **prevalent in the basins** of the Indus, Krishna, Cauvery, Subarnarekha, Pennar, Mahi, Sabarmati & east-flowing rivers, and west-flowing rivers of Kutch and Saurashtra, including Luni.

35.2.1. Per-Capita water situation

- According to the CWC, per capita availability in the country will decrease from 1,434 cubic metres in 2025 to 1,219 cubic metres in 2050.
- As per CWC benchmarks:
  1) 1700 cubic meters/person/year – 1000 cubic meters/person/year = **Water Stressed Condition**.
  2) Less than 1000 cubic meters/person/year = **Water Scarcity Condition.**
  3) 1000 cubic meters/person/year – 500 cubic meters/person/year = **Chronic Water Scarcity**.
  4) **Less than 500 cubic meters/person/year = Absolute Scarcity**.

35.2.2. India's groundwater situation

- According to 'Water and Related Statistics 2019' by the CWC, the annual replenishable groundwater resources in India (2017) are 432 BCM, out of which 393 BCM is the yearly "extractable" groundwater availability.
- The current annual groundwater extraction is 249 BCM, the **largest user being the irrigation sector.**
- The **CGWB has classified** the country's assessment units (blocks, taluks, mandals, etc.) into **safe, semi-critical and over-exploited** in terms of groundwater resources.
- Jal Shakti Ministry had said **14% of the country's assessment units are semi-critical, 5% are critical, and 17% are over-exploited**, as of 2017.

Consider the following statements:

1. 36% of India's districts are classified as "overexploited" or "critical" by the Central Ground Water Authority (CGWA).
2. CGWA was formed under the Environment (Protection) Act.
3. India has the largest area under groundwater irrigation in the world.

Which of the statements given above is/are correct?

a) 1 only
b) 2 and 3 only
c) 2 only
d) 1 and 3 only

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Explanation:

- **Critical 5% + over-exploited 17% = 22%.**
- **Semi-critical 17% + Critical 5% + over-exploited 14% = 36%.**
- India has the largest area under groundwater irrigation, followed by China.

Answer: b) 2 and 3 only

- India is the **2nd largest producer of wheat in the world**.
- But with severe groundwater depletion, the cropping intensity in the winter season may decrease by up to 20% by 2025. (Some of the important **winter crops are wheat, barley, mustard & peas**)
- 13% of the villages in which farmers plant a winter crop are in critically water-depleted regions.
- A study has now pointed out that India could experience **more flash droughts** by the end of this century.
- Even if all regions that are currently using depleted groundwater for irrigation will switch to using canal irrigation, cropping intensity may decline by 7% nationally.
- About **85% of the rural water supply** in India is dependent on groundwater.
- Due to the rampant drawing of subsurface water, the **water table in many regions** of the country has **dropped significantly** in recent years resulting in a threat to groundwater sustainability.
- The **Indo-Gangetic Plain, North-western, Central & Western parts** of India account for most intensive groundwater-based irrigation.
- And among these regions, **Western India & the Indo-Gangetic Plain** have **more than 90% of the area irrigated using groundwater**.
- An average drop in groundwater level by 1 m would **increase India's total carbon emissions by over 1%**.

Causes for depletion

- **Unsustainable usage** of water.
  - ✓ Frequent pumping of water from the ground.
  - ✓ Usage rate is greater than Recharge rate.
- **Low-intensity rainfall** during the monsoon.
- Agricultural needs require a large amount of groundwater.
- Groundwater depletion is further worsened by the substantial increase in the **concurrent hot & dry monsoon** in India.
- Green Revolution **era led to unsustainable groundwater use for irrigation:**
  - ✓ Green Revolution led to a large **increase in rice cultivation** in north-western India, mainly in Punjab & Haryana, which are less suitable for rice cultivation due to **predominantly light soils**.
- There are **limited storage facilities** owing to the **hard rock terrain in central India**.

Effects

- Large bodies of water will become shallower from groundwater depletion.
- As large aquifers are depleted, the food supply & people will suffer.
- A lack of groundwater limits biodiversity & dangerous sinkholes result from depleted aquifers.

35.3. List of measures by the Central Government

- Water being a **state subject**, steps for conservation is undertaken by the State government where the Central Government supplements the efforts.
- **National Water Policy (2012)** has been formulated by the Department of Water Resources:
  - ✓ It advocates for **rainwater harvesting & conservation of water**.

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- ✓ It highlights the need for augmenting the availability of water through direct use of rainfall.
- **Central Ground Water Authority (CGWA)** has issued directions under the **Environment Protection Act, 1986** for mandatory Rain Water harvesting for all target areas in the country, including UTs.
- **Central Ground Water Board (CGWB)** prepared a document entitled "**Master Plan for Artificial Recharge to Ground Water in India"** during the year 2013:
  - ✓ It envisages the construction of 1.11 crore rainwater harvesting & artificial recharge structures in the country by harnessing surplus monsoon runoff to augment groundwater resources.
- **Ministry of Housing & Urban Affairs** has released **Model Building Bye-laws, 2016:**
  - ✓ It recommends Rainwater Harvesting for all types of buildings with a plot size of 100 sq. m or more.
  - ✓ **It aims for sustainable management of groundwater resources** with community participation in water-stressed blocks of Gujarat, Haryana, Karnataka, MP, Maharashtra, Rajasthan&Uttar Pradesh.
- Creation of a **new Ministry of Jal Shakti** for dealing with **all matters relating to water at one place in an integrated manner.**
  - ✓ It has been created by the **merger of Ministries of Water Resources, River Development & Ganga Rejuvenation, along with Drinking Water & Sanitation**.
- The government has **launched various schemes&programmes:**
  - ✓ **Atal Bhujal Yojana (Atal Jal)**
  - ✓ **Jal Shakti Abhiyan** for water conservation launched that would focus on 1,592 "water-stressed" blocks in 257 districts.
  - ✓ **Jal Jeevan Mission (JJM)**.
  - ✓ **Micro Irrigation Fund under NABARD.**
  - ✓ **National Perspective Plan (NPP)** has been formulated for water resources development to transfer water from surplus to deficit areas.
- Projects related to rainwater harvesting, rejuvenation of water bodies, recharging of groundwater through:
  - ✓ **AMRUT Mission**
  - ✓ **Mahatma Gandhi National Rural Employment Guarantee Scheme** (**MGNREGS**)
  - ✓ **Pradhan Mantri Krishi Sinchayee Yojana – Watershed Development Component** (**PMKSY-WDC**).

35.3.1. Central Ground Water Board (CGWB)

- Central Ground Water Board (CGWB) is a **subordinate office & the apex organization** of the **Ministry of Water Resources** dealing with **groundwater and related issues.**
- It is mandated to develop and disseminate technologies & monitor & implement national policies for the scientific and sustainable development and management of India's groundwater resources.
- The government has constituted the **Central Ground Water Authority (CGWA)** that works under the department of **water resources, Ministry of Jal Shakti**.
- **Central Ground Water Authority has been constituted under Environment (Protection) Act, 1986** to regulate & control the development & management of **groundwater resources** in the country.

Powers & Functions:

- The authority has been conferred with the following powers:
  1. Exercise of powers under Environment (Protection) Act, 1986
  2. To resort to penal provisions
  3. To regulate & control, management & development of groundwater in the country
  4. Exercise of powers under Environment (Protection) Act, 1986 for the appointment of officers.

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Regulatory Measures

- The Central Ground Water Authority is **regulating the withdrawal of groundwater** by industries/ projects in **802 Over-exploited** & **169 Critical Assessment Units**.
- A list of these critical areas has been circulated to the **State Pollution Control Boards & the Ministry of Environment & Forests,** which refer the new industries/ projects to **CGWA for obtaining permission**.
- CGWA has notified 162 critical/ overexploited areas for control & regulation of the development of groundwater resources.
- **Construction of new groundwater structures is prohibited in the notified areas**.

NGT vs. CGWB

- NGT has **struck down the Central Ground Water Authority's (CGWA) 2020 guidelines,** saying they were against the law.
- NGT ordered commercial entities to follow new rules for getting permission to extract groundwater.

NGT Guidelines

- **Environmental Impact Assessments (EIA)** will now form the basis of granting such permissions.
- There must be **no general permission for withdrawal of groundwater,** particularly to any commercial entity, without EIA of such activity.
- **Water management plans** need to be prepared for all OCS (overexploited, critical & semi-critical) assessment units in the country based on the mapping data, starting with overexploited blocks.
- Permission to extract groundwater **must be for specified times & quantity of water**, not for perpetuity.

Why such guidelines?

- There was no claim over groundwater levels improving, nor was there a projection for future improvement in the past 23 years of regulation by the CGWB.
- India was at the bottom of the water quality index, at **120 among 122 countries**.
- Most states achieved less than half the total score in the augmentation of groundwater resources.
- Almost none of the states have built the infrastructure required to recharge groundwater in over-exploited & critical areas wither.
- **India accounted for 25% of the total annual global water extracted**.

35.3.2. Central Water Commission

- It was established in **1945.**
- It is a **technical organization** that functions as part of the **Ministry of Jal Shakti**.
- It is entrusted with providing consultation to various state governments on water bodies related issues, coordinate various governmental schemes for conservation, control, and utilization of water resources.
- It has the responsibility of **initiation and coordination of schemes** introduced by the Ministry of Jal Shakti.
- They include schemes to conserve as well as control the water resource usage in the country and the States.
- The schemes also help in the fields of **flood management, irrigation activities, drinking water supply, hydroelectricity generation,** etc.

35.3.3. National Aquifer Mapping & Management Programme (NAMMP)

- Aquifer mapping is a process to characterize the **quantity, quality & sustainability of groundwater** in aquifers.
- NAMMP is a **central sector scheme** of the **Department of Water Resources**.

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- Under the initiative, the existing available information of aquifer is compiled, synthesized & data gaps are filled through new data generation.

Objectives of Programme

- Delineation & characterization of aquifers in 3D to understand their disposition.
- Identification & quantification of groundwater issues.
- Development of groundwater management plans.

35.3.4. Atal Bhujal Yojana (ATAL JAL)

- ATAL JAL is a Rs.6000 crore **World Bank** approved **Central Sector Scheme** of the **Ministry of Jal Shakti**.
- The funding pattern is **50:50 between the Government of India and the World Bank**.
- The scheme will be implemented over a period of **5 years (2020-21 to 2024-25)**.
- It aims to improve **groundwater management in priority areas through community participation**.
- The priority areas identified under the scheme fall in the states of **Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan** and **Uttar Pradesh**.
- They also cover two major types of groundwater systems found in India – **alluvial and hard rock aquifers** – and have varying degrees of institutional readiness and experience in groundwater management.

Features of ATAL JAL Scheme

- ATAL JAL will promote **panchayat led groundwater management** & behavioural change with a primary focus on demand-side (water consumption) management.
- It envisages community-led **Water Security Plans**.
- Concepts such as 'Water User Associations' and **Water Budgeting** will be introduced.
- Better performing districts and panchayats will get more funds.

35.3.5. Failure of Jal Shakti Abhiyan

- GOI launched the **Jal Shakti Abhiyan (JSA)**, a time-bound **water conservation campaign** to be carried out in two phases across the 255 districts having critical and over-exploited groundwater levels.
- JSA was **not a funding programme** & **did not create any new intervention on its own**.
- It only aimed to make water conservation a **'people's movement'** through schemes like the MGNREGA.
- These projects primarily involved building tanks & ponds in capturing rainwater and building recharge wells.

Reasons for the failure of Jal Shakti Abhiyan

Not much scientific planning went into JSA

- Water planning should be based on hydrological units like river basins & catchment areas.
- However, JSA was planned based on administrative boundaries.
- This resulted in the division of basins/aquifers into multiple units that followed multiple policies.
- There was no data on basin-wise rainfall, no analysis of runoff and groundwater maps were rarely used.
- As a result, whether water harvested in a district was sometimes at the cost of water in adjoining districts.
- The JSA ignored the fact that most of India's water-stressed basins, particularly those in the peninsular regions, are facing closure, with the demand exceeding supply.
- Hence, groundwater recharge happened at the cost of surface water and vice versa.

Facile assumptions

- The per capita water allocation was 55 litres for rural &135-150 litres for those living in urban areas.

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- However, JSA stressed the rural areas and conveniently ignored the urban areas.
- Therefore, the JSA's asking villagers to save water appears hypocritical, particularly when district administrations blatantly allow the sewage generated from cities to pollute village water sources.

Lack of long-term solutions

- Most of the farm bunds built with soil collapse within one monsoon season due to rains.
- There are issues like lack of proper engineering supervision of these structures, involvement of multiple departments with less or no coordination, and limited funding under MGNREGA and other schemes.
- Finally, there have hardly been any efforts undertaken to dissuade farmers from growing water-intensive crops such as paddy, sugarcane, and banana.

Q. What are the salient features of the Jal Shakti Abhiyan. launches by the Government of India for water conservation and water security? (UPSC CSE Mains 2020 – 250 words).

35.3.6. Jal Jeevan Mission (JJM)

- Jal Jeevan Mission, **launched in 2019,** envisions providing **safe and adequate drinking water through individual household tap connections by 2024** to all households in **rural India**.
- The programme will also implement **source sustainability measures** as mandatory elements, such as **recharge and reuse** through **grey water (used wastewater that has not come into contact with faeces)** **management**, **water conservation, rainwater harvesting**, etc.
- JJM will be based on a **community approach to water (Jan Andolan for water— making water everyone's priority)** and will include extensive information, education, and communication as a key component.
- The **mission will converge** with other **Central and State Government Schemes** to achieve its objectives of sustainable water supply management across the country.
- The **Jal Shakti Ministry** is the nodal ministry for the implementation of the mission.
- The **fund sharing pattern between the Centre and states** is **90:10 for Himalayan and North-EasternStates**, **50:50 for other states**, and **100% for Union Territories**.

Jal Jeevan Mission (URBAN)

- JJM Urban has been announced under the **Housing and Urban Affairs Ministry**.
- It aims to provide universal coverage of water supply to all households through functional taps in all statutory towns in accordance with **Sustainable Development Goal- 6 (clean water and sanitation for all)**.
- It **complements** the Jal Jeevan Mission (Rural).

Objectives

- It proposes to **cover the estimated gap:**

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- ✓ 2.68 crore in urban household tap connections.
- ✓ 2.64 In sewer connections in 500 AMRUT cities.
- Rejuvenation of water bodies to augment sustainable fresh water supply and **creating green spaces**.
- To reduce floods and enhance amenity value through **Urban Aquifer Management plans**.
- To promote the **circular economy of water** through focusing on **recycle/reuse** of treated sewage, rejuvenation of water bodies and water conservation.
- To spread awareness among masses through **Information, Education & Communication campaign.**
- To conduct **Pey Jal Survekshan** in cities to ascertain:
  - ✓ Equitable distribution of water.
  - ✓ Reuse of wastewater.

35.3.7. BIS – Drinking Water Standards

- BIS recommends the **acceptable limits of substances to be implemented in drinking water.**

Substance/Characteristic	Requirement (Acceptable Limit)	Permissible limit
pH Value	**6.5 – 8.5**	**No relaxation**
Total Dissolved Solid	**500 mg/l**	**2000 mg/l**
Aluminium	0.03	0.2
Ammonia	**0.5**	**No relaxation**
Calcium	75	200
Chloride	250	1000
Fluoride	**1.0**	**1.5**
Arsenic	**0.01**	**0.05**
Iron	**0.3**	**No relaxation**
Sulphide	0.05	No relaxation
Nitrate	**45**	**No relaxation**
Copper	0.05	1.5
Total Hardness (CaCo3)	**200**	**600**

BIS' Public Drinking Water Supply Draft

- BIS has prepared a draft **'Drinking water supply quality management system requirements for piped drinking water'** standard for the supply system of piped drinking water.
- The draft has been prepared by the **BIS' Public Drinking Water Supply Services Sectional Committee**.
- It outlines the process of water supply, from raw water sources to household taps.
- It has been developed keeping in view the **Centre's Jal Jeevan Mission** for providing **safe & adequate drinking water to all rural households by 2024 through tap connections**.
- The draft outlines the requirements for a water supplier on how they should establish, operate, maintain & improve their piped drinking water supply service.
- It sets the **Indian Standard (IS) 10500** for the treated water for drinking.
- The **IS 10500** outlines the acceptable limit of **heavy metals such as arsenic, pH value of water, turbidity, the total dissolved solids** in it, and the **colour and odour**.
- Adoption of the concept of **District Metering Area (DMA)** where it is possible.
- DMA is a concept for **controlling leakages in the water network**.
- The draft also mentions that **water should be sampled at the treatment plant every four hours** against quality parameters.

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Bureau of Indian Standards (BIS)

- BIS is the **National Standard Body of India** established under the **BIS Act 2016** for the harmonious development of the activities of **standardization, marking & quality certification of goods**.
- BIS is involved in various activities as given below:
  - ✓ Standards Formulation
  - ✓ Product Certification Scheme
  - ✓ Compulsory Registration Scheme
  - ✓ Foreign Manufacturers Certification Scheme
  - ✓ Hall Marking Scheme
  - ✓ Laboratory Services
  - ✓ Laboratory Recognition Scheme
  - ✓ Sale of Indian Standards
  - ✓ Consumer Affairs Activities, etc.

35.3.8. National Hydrology Project (NHP)

- NHP is a pan India **Central Sector Scheme**, with a **100% grant to the States**.
- It is to be implemented for **8 years** from 2016-17 to 2023-24.
- It is **World Bank** assisted scheme.
- NHP intends to provide a system for real-time water resources data acquisition, storage, collation & management.
- It will **reduce the vulnerability of many regions to recurring floods & droughts** as the absence of real-time ground information for the entire country creates difficulties in issuing alerts on time.
- NHP data will be stored on a real-time basis & can be accessed by users at the State/District/village level.
- The objectives of the project are to
  - ✓ **improve reliability & accuracy of Hydrology & Ground Water data throughout India,**
  - ✓ establish an effective hydrological database & improve access to it,
  - ✓ design aids to assist in the effective water resources planning & management,
  - ✓ build resilience against flooding & droughts due to uncertainties of climate change.

35.4. Recommended Measures

35.4.1. Clean water sanctuaries

- Over 70% of India's surface water (rivers and lakes) and groundwater is polluted.
- Indians will soon need reverse osmosis (RO) for homes, which will add to the existing burden.
- The only unpolluted sources of water that remain are the
  - ✓ **waters underlying the floodplains of rivers** (for bulk water) and
  - ✓ **subterranean natural mineral water underlying forest tracts** (for drinking).
- These are two non-invasive sources that can perennially provide unpolluted water to the masses.
- Floodplains can be secured by planting organic food forests or fruit forests which don't consume much water.
- Carving out lakes, as has been lately suggested, would require digging out vast quantities of sand.
- This will affect the wetland ecology of the floodplains. It will also cause a **loss of water due to evaporation**.
- The natural mineral water that underlies forests is of the highest international quality.
- Unpolluted **rainwater percolates through** the humus or leaf cover on the forest floor while picking up nutrients and then through the underlying rock while picking up minerals.

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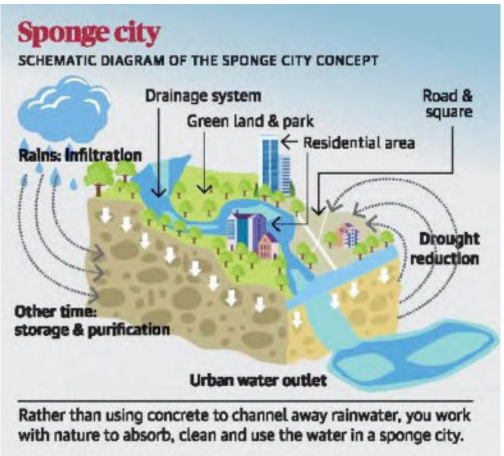
- It finally settles in underground aquifers. This is the highest quality **natural mineral water for drinking**.
- All our villages and cities in the sweep of the **Western and Eastern Ghats have such forest aquifers**.

35.4.2. Sponge City Concept



- The Sponge City indicates a particular type of city **that does not act like an impermeable system,** not allowing any water to filter through the ground.
- It **acts like a sponge & absorbs the rainwater**.
- It is then naturally filtered by the soil & allowed to **reach into the urban aquifers.**
- This allows for the extraction of water from the ground through urban or peri-urban wells.
- This water can be easily treated and used for the city water supply.
- System in which water is **Conserved+ Stored+ Recharged+ Sustainable** use is practised.

What does a Sponge City need in practice?

- A sponge city **needs to be abundant with spaces that allow water to seep through them.**
- Instead of only impermeable concrete and asphalt, the city needs more:
  - ✓ Contiguous open green spaces, interconnected waterways, channels and ponds across neighbourhoods.
  - ✓ **Green roofs** that can retain rainwater and naturally filters it before it is recycled or released into the ground.

What are the benefits of a Sponge City?

- Replenished groundwater and thus greater accessibility to water resources for cities.
- Cleaner groundwater due to the increased volume of naturally filtered stormwater.
- **Reduction in flood risk** as the city offers more permeable spaces for the natural percolation of water.
- Lower burdens on drainage systems, water treatment plant, artificial channels and natural streams.
- Greener, healthier, more enjoyable urban spaces.
- Enriched biodiversity around green open spaces, wetlands, urban gardens and green rooftops.

35.5. Droughts

- Flash droughts are droughts that **intensify more rapidly than normal**, posing a risk to agriculture, ecosystems & water availability.
- **Flash drought** develops at an **unusually fast rate** due to **extreme weather conditions** & persists from a few weeks to some months.
- **Conventional droughts,** on the other hand, take months to years to develop to full intensity.
- Flash droughts can be localized to a specific region or can become widespread.

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- Several factors, including atmospheric anomalies, anthropogenic GHG emissions, play an important role.
- **In 1979, India faced a severe flash drought, affecting about 40% of the country**.

35.5.1. What is Drought?

- As defined by the IMD, drought is a consequence of the **natural reduction in the amount of precipitation for a long period of time**.
- It is associated with other climatic factors like **high winds & temperatures** & **low relative humidity**.
- These factors can aggravate the severity of the drought event.
- As per the **Manual for Drought Management 2016**, drought is declared considering the following two indicative factors:
    1. **The extent of rainfall deviation (depreciation)**
    2. **The consequent dry spell**
- A **drought year** is defined by the Indian Meteorological Department (IMD) as a year in which:
    - ✓ The overall rainfall deficiency is **more than 10% of the Long Period Average value (LPA) value**; and
    - ✓ If more than **20% of its area is affected by drought conditions, either moderate or severe or combined moderate&severe.**
- When the spatial coverage of drought is **more than 40%**, it will be called **All India Severe Drought Year**.
- The 2009 Manual of Drought Management classifies droughts into 3 categories:
    1. **Meteorological drought**
    2. **Hydrological drought**
    3. **Agricultural drought**

35.5.2. International Efforts for Drought Management

- The **United Nations Development Programme (UNDP)**launched the **Integrated Drylands Development Programme (IDDP):**
- It aims to strengthen resilience by working on the **twin vulnerabilities** of
    - ✓ **Poverty** &
    - ✓ **Unsustainable land management in the drylands**.
- The **United Nations Office for Disaster Risk Reduction (UNISDR)** developed a **Drought Risk Reduction framework** that provides a comprehensive framework for both higher-level & local action.
- In 2013, the **World Meteorological Organization (WMO)** and the **Global Water Partnership (GWP)** launched the **Integrated Drought Management Programme (IDMP)** to address drought issues.
- The **IDMP** & its partners have adopted 3 pillars of drought management.
    1. **Monitoring & Early Warning Systems**: Monitoring & analyzing drought indicators such as precipitation, temperature etc.
    2. **Vulnerability & Impact Assessment:** It considers social, economic & environmental factors to determine a community's susceptibility to drought hazards.
    3. **Mitigation & Response:** Drought mitigation includes both the structural (i.e., appropriate crops, dams & engineering projects) & non-structural measures (i.e., policies, public awareness, & legal framework).

35.5.3. Drought Management in India

- There is **no single, legally accepted definition of drought in India**.
- Some states resort to their own definitions of drought.
- **State Government is the final authority** when it comes to declaring a region as drought-affected.

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- India has published two important documents in respect of managing a drought.
  1. **Manual for Drought Management, 2009** by **Ministry of Agriculture** (not Ministry of Earth Sciences).
  2. **Guidelines for Management of Drought, 2010** by **National Disaster Management Authority**.
- However, these documents **have no binding force** & are mere guidelines to be followed, if so advised.
- **Drought would certainly fall within the definition of "disaster"** as defined under Section 2(d) of the Disaster Management (DM) Act, 2005 – SC in Swaraj Abhiyan Vs Union of India in 2016.
  - ✓ **National Disaster Management Authority (NDMA)** to be the **agency responsible for drought management,** particularly with respect to chalking out long term preventive & mitigation measures.
  - ✓ However, the **state government concerned would be the final authority to declare a drought**.
  - ✓ **Droughts can also be declared for a particular village in a district or a taluka or tehsil or block**.

35.5.4. Way forward

- Need for efficient **drought monitoring & early warning systems** in India.
- **Drought Vulnerability & Impact Assessment** needs to be done at regular intervals.
- **Framework for the Assessment** of **Benefits of Action or Cost of Inaction (BACI)** for Drought Preparedness must be adopted:
  - ✓ It suggests a methodological framework for the assessment of **BACI** as a tool to support a shift in drought policy & programs from **crisis management to a risk management approach**.
- **National Drought Management Policy Guidelines** must be included while formulating policies:
  - ✓ It was codified by the **WMO** & the **Global Water Partnership (GWP)**.
  - ✓ It provides a template for action that countries can use in the development of a national drought management policy & drought preparedness/mitigation plans.
- **Preventive Methods:**
  - ✓ Judicious use of surface & groundwater.
  - ✓ **Cloud seeding in drought Prone regions** of India.
  - ✓ Use of modern micro-irrigation methods like drip & sprinkler irrigation.
  - ✓ Afforestation
  - ✓ Use of traditional water conservation & storage techniques.
- **Mitigation measures**
  - ✓ Contingency Crop Planning by providing other options to farmers like **drought resistant crops**.
  - ✓ Arrangement must be made for relief employment programmes on the lines of MGNERGA.
  - ✓ **Crop Insurance schemes** like PM Fasal Bima Yojna.

Mains Practice: *There is a need for a robust & effective national drought management framework in India. Analyse* ***(250 words)***

35.5.5. Measures Required for Water Conservation

- We need better policies in eastern India **to expand the irrigation**&thus increase agriculture productivity. This will also release some pressure from north-western Indian states.
- Water resource management plans need to **incorporate the effects of climate change** in order to accurately predict future supplies.
- **Traditional water conservation/harvesting methods must be revived** like:
  - ✓ Constructing farm ponds, check dams, gully plugging, dug wells, borewells.
  - ✓ Artificial glaciers in Ladakh.
  - ✓ Tamaswada Pattern nallahs treatment in Maharashtra.

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- **Need for greater regulation & strict penalties:**
  - ✓ Currently, regulations are more of a toothless tiger.
- Encouraging farmers to **adopt micro-irrigation techniques** such as drip irrigation & micro-sprinklers.
  - ✓ The government has initiated schemes like **DRIP programme, more drop per crop, Krishi Sinchai Yojana** to ensure economical water use practices in agriculture.
- **Artificial recharge** of tube wells, water reuse, afforestation, scientific methods of agriculture should also be done.
- It is **recommended to study the aquifer geometry:**
  - ✓ Establish the saline fresh interfaces within a few km of the coastal area.
  - ✓ To study the effects of glaciers melting on the recharge potential of aquifers in the Ganga basin & its effects on the transboundary aquifer systems, particularly in the arid & semi-arid regions.

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36. Biodiversity of India

- The **mega-diverse countries** are those whose ecosystems have **extraordinarily rich biodiversity** supporting the majority of the earth's species, including a **large number of endemic species**.
- Although they only account for around 10% of the earth's surface, the mega-diverse countries house at least 70% of the planet's terrestrial biological diversity.
- The **World Conservation Monitoring Centre (WCMC)** of the **United Nations Environment Program** has identified a total of **17 mega-diverse countries**: **Australia, Brazil, China, Colombia, Ecuador, United States, Philippines, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Democratic Republic of Congo, South Africa and Venezuela**.

- India is one of the **mega-diverse countries**, rich in biodiversity and associated traditional knowledge.
- India has **24.56% of its geographical area under forest and tree cover**.
- With just **2.4% of the land area**, India accounts for nearly **7-8%** of the recorded species, even while supporting almost 18% of the human population.

Group	Number of species in India (SI)	Number of species in the world (SW)	SI/SW (%)
Mammals	350(1)	4,629(7)	7.6
Birds	1224(2)	9,702(8)	12.6
Reptiles	408(3)	6,550(9)	6.2
Amphibians	197(4)	4,522(10)	4.4
Fishes	2546(5)	21,730(11)	11.7
Flowering Plants	15,000(6)	250,000(12)	6.0

India Represents

- Two 'Realms'
- Five Biomes
- Ten Bio-geographic Zones
- Twenty-five Bio-geographic provinces

36.2. Realms

- Biogeographic realms are **large spatial regions within which ecosystems share a broadly similar biota**.
- A realm is a continent or sub-continent sized area with unifying features of geography and fauna & flora.
- The Indian region is composed of two realms. They are:
  1) the Himalayan region represented by Palearctic Realm and
  2) the rest of the sub-continent represented by the Malayan Realm
- In the world, Eight terrestrial biogeographic realms are typically recognised.
- They are:
  1) Nearctic Realm
  2) Palaearctic Realm

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3) Africotropical Realm
4) Indomalayan Realm
5) Ocenaia Realm
6) Australian Realm
7) Antarctic Realm
8) Neotropical Realm

36.3. Biomes of India

- The term biome means the **main groups of plants and animals living in areas of certain climate patterns**.
- It includes the way in which animals, vegetation and soil interact together. The plants and animals of that area have adapted to that environment.

The five biomes of India are:

1) **Tropical Humid Forests**
2) **Tropical Dry or Deciduous Forests (including Monsoon Forests)**
3) **Warm deserts and semi-deserts**
4) **Coniferous forests and**
5) **Alpine meadows.**

36.4. Biogeographic Zones

- Biogeography deals with the **geographical distribution of plants and animals**.
- Biogeographic zones were used as a **basis for planning wildlife protected areas in India**.
- There are 10 biogeographic zones that are distinguished clearly in India.
- They are as follows:
    1) **Trans-Himalayas**
    2) **Himalayas**
    3) **Desert**
    4) **Semi-arid**
    5) **Western Ghats**
    6) **Deccan Peninsula**
    7) **Gangetic plain**
    8) **North-east India**
    9) **Islands**
    10) **Coasts**

36.5. Biogeographic Provinces

- Bio-geographic Province is an ecosystematic or **biotic subdivision of realms**.
- India is divided into 25 bio geographic zones.

Biogeographic Zones (10)	Biogeographic Provinces (25)
1) Trans Himalaya	**1) 1A: Himalaya – Ladakh Mountains** **2) 1B: Himalaya – Tibetan Plateau** **3) 1C: Trans – Himalaya Sikkim**
2) The Himalaya	**4) 2A: Himalaya – North West Himalaya** **5) 2B: Himalaya – West Himalaya**

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	6) 2C: Himalaya – Central Himalaya **7) 2D: Himalaya – East Himalaya**
3) The Indian Desert	**8) 3A: Desert – Thar** **9) 3B: Desert – Kutch**
4) The Semi-Arid	**10) 4A: Semi-Arid – Punjab Plains** **11) 4B: Semi-Arid – Gujarat Rajputana**
5) The Western Ghats	**12) 5A: Western Ghats – Malabar Plains** **13) 5B: Western Ghats – Western Ghats Mountains**
6) The Deccan Peninsula	**14) 6A: Deccan Peninsular – Central Highlands** **15) 6B: Deccan Peninsular – Chotta Nagpur** **16) 6C: Deccan Peninsular – Eastern Highlands** **17) 6D: Deccan Peninsular – Central Plateau** **18) 6E: Deccan Peninsular – Deccan South**
7) The Gangetic Plains	**19) 7A: Gangetic Plain – Upper Gangetic Plains** **20) 7B: Gangetic Plain – Lower Gangetic Plains**
8) The Coasts	**21) 8A: Coasts – West Coast** **22) 8B: Coasts – East Coast** **23) 8C: Coasts – Lakshadweep**
9) Northeast India	**24) 9A: North-East – Brahmaputra Valley** **25) 9B: North-East – North East Hills**
10) Islands	**26) 10A: Islands – Andaman** **27) 10B: Islands – Nicobars**

36.6. Wildlife Diversity of India

36.6.1. Himalayan mountain system

- The west Himalayas have low rainfall, heavy snowfall (temperate conditions).
- In the east Himalayas, there is heavy rainfall, snowfall only at very high altitudes.
- Lower altitudes conditions are similar to the tropical rain forests.

Himalayan Foothills

- Flora: Natural monsoon evergreen and semi-evergreen forests; dominant species are **sal, silk-cotton trees, giant bamboos; tall grassy meadow with savannahs in terai**.
- Fauna: **Elephant, sambar, swamp deer, cheetal, hog deer, barking deer, wild boar tiger, panther, hyena, black bear, sloth bear, Great Indian one-horned rhinoceros, wild buffalo, Gangetic gharial, golden langur.**

Western Himalayas (High Altitude Region)

- Flora: Natural monsoon evergreen and semi-evergreen forests; **rhododendrons; dwarf hill bamboo and birch forests mixed with alpine pastures**.
- Fauna: **Tibetan wild ass (kiang) (Don't confuse this with Asiatic wild ass which in found in Kutch region), wild goats (thar, ibex) and blue sheep; antelopes (Chiru and Tibetan gazelle), deers (hangul of Kashmir stag and shou or Sikkim stag, musk deer); golden eagle, snow cocks, snow partridges; snow leopard, black and brown bears; birds like Griffon vultures.**

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Q. What is the difference between the antelopes Oryx and Chiru?

a) Oryx is adapted to live in hot and arid areas whereas chiru is adapted to live in steppes and semi-desert areas of cold high mountains.
b) Oryx is poached for its antlers whereas chiru is poached for its musk.
c) Oryx exists in western India only whereas chiru exists in north-east India only.
d) None of the statements a, b, and c given above is correct.

Explanation:

Answer: a)

Eastern Himalayas

- Flora: **Oaks, magnolias, laurels and birches** covered with moss and ferns; coniferous forests of pine, fir, yew and junipers with an undergrowth of scrubby **rhododendrons** and dwarf bamboos; lichens, mosses, orchids, and other epiphytes dominant (due to high humidity and high rainfall).
- Fauna: **Red panda, hog badgers, forest badgers, crestless porcupines, takins etc.**

36.6.2. Peninsular – Indian sub-region

- It has two zones.
  a) peninsular India and its extension into the drainage basin of the Ganges river system, and
  b) desert region of Rajasthan-the Thar of Indian desert region.

Peninsular India

- It is home to tropical moist deciduous to tropical dry deciduous and scrub vegetation depending upon the variation in rainfall and humidity.
- Flora: **Sal** in north and east extensions (higher rainfall) and **teak** in southern plateau are dominant trees.
- West Ghats have evergreen vegetation (flora and fauna similar to the evergreen rainforests of north-eastern India. In dry areas of Rajasthan and Aravalli hills, trees are scattered, and thorny scrub species predominate. The forests give way to more open savannah habits.
- Fauna: **Elephant, wild boar, deers (cheetal or axis deer), hog deer swamp deer or barasinga, sambar, muntjak or barking deer, antelopes (four-horned antelope, Nilgiri, blackbuck, chinkara gazelle), wild dog or dhole, tiger, leopard, cheetah, lion, wild pig, monkey, striped hyena, jackal, gaur.**

36.6.3. Indian desert

- Thar desert of Rajasthan has unique flora and fauna.
- Flora: Thorny trees with reduced leaves; cacti, other succulents are the main plants.
- Fauna: Animals are mostly burrowing ones. Among mammals' rodents are the largest group.
- The Indian desert gerbils are mouse-like, rodents, other animals are, **Asiatic wild ass, blackbuck, desert cat, caracal, red fox; reptiles** (snakes, lizards and tortoise) well represented.
- Desert lizards include agamids and geckos. Among birds, the most discussed is **Great Indian Bustard**.

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36.6.4. Tropical Rain Forest Region

- They are distributed in areas of the Western Ghats and northeast India.
- Flora: Extensive grasslands interspersed with densely forested gorges of evergreen vegetation known as sholas occur in the Nilgiris (an offshoot of Western Ghats). **Sholas** also occur in Annamalai and Palani hills.
- The rain forests of the Western Ghats have dense and lofty trees with much species diversity. Mosses, ferns, epiphytes, orchids, lianas and vines, herbs, shrubs make diverse habitat. **Ebony** trees predominate in these forests.
- Fauna: It is very rich with all kinds of animals. There are wild **elephants, gaur and other larger animals.**
- **Most species are tree dwellers. The most prominent are hoolock gibbon (only ape found in India), golden langur, capped langur or leaf monkey, Assam macaque and the pig-tailed macaque, lion-tailed macaque, Nilgiri langur slender loris, bats, giant squirrel, civets, flying squirrels, Nilgiri mongoose, spiny mouse.**

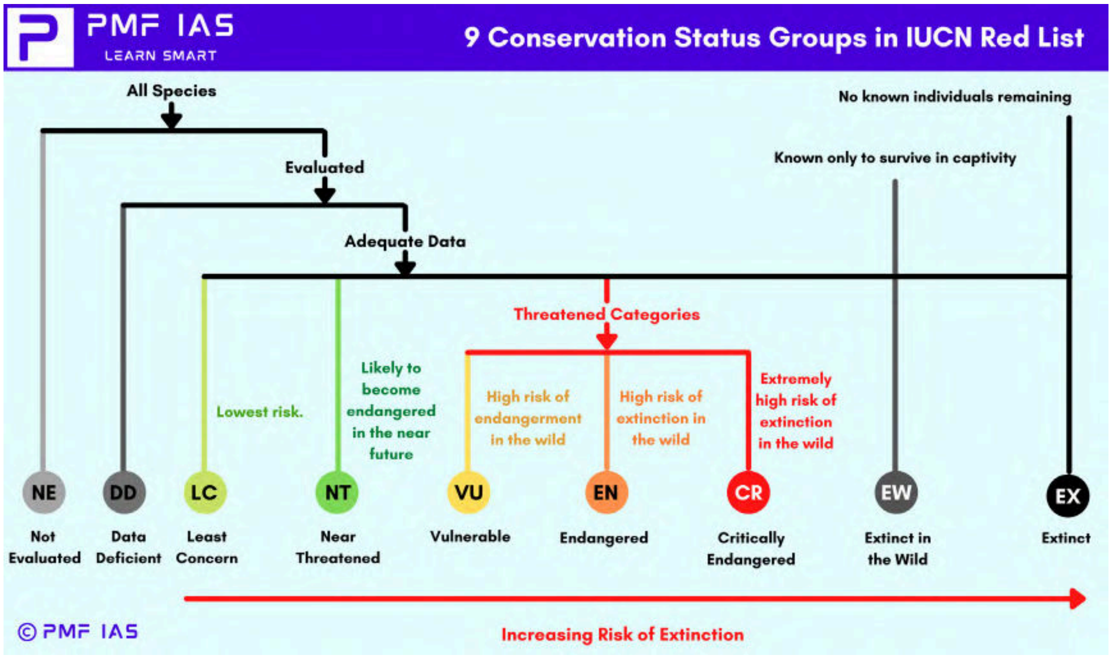
36.6.5. Andaman and Nicobar Islands

- Flora: These are home to tropical rain forests. Mangroves are distributed in the coastal areas.
- Fauna: Among mammals, bats and rats; **Andaman pig, crab-eating macaque, palm civet and deers** (spotted deer, barking deer, hog deer, sambar).
- Among marine mammals, there are **dugongs, false killer whales, dolphins**.
- Among birds are rare one is **Narcondum hornbill, white-bellied sea-eagle**.
- **Salt-water crocodile**, a number of marine turtles, coconut crab, lizards (the largest being water monitor), 40 species of snakes, including cobra, viper, sea snake, python, etc. are present.

36.6.6. Mangrove swamps of Sundarbans

- Sundarbans are the delta of the Ganges, where both the Brahmaputra and the Ganges join and drain into the Bay of Bengal.
- Flora: Various species of mangroves.
- Fauna. In the higher regions of mangroves, there are spotted deer, pigs, monitor lizard, monkeys. The most interesting animal of Sundarbans is the **Royal Bengal Tiger**.

36.7. Conservation Status and Range of Major Flora and Fauna of India



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36.7.1. Mammals – Critically Endangered (CR)

Mammals – CR – Andaman White Toothed Shrew

- **Andaman White Toothed Shrew (CR)** is a small mouse-like mammal.
- **Distribution:** It is **endemic** to the **South Andaman Island**.
- They are usually active by twilight or in the night i.e., **nocturnal.**

- **Threats:** Habitat loss due to selective logging, natural disasters such as tsunami & drastic weather change.
- **Conservation Status:**
  - **IUCN Red List Status: Critically Endangered**

Note: Scientists from **Zoological Survey of India (ZSI)** have discovered a new species of white-toothed shrew, from **Narcondam Island** of the Andaman and Nicobar group of islands.

Mammals – CR – Chinese Pangolin

- **Chinese Pangolin (CR)** is a **nocturnal ant-eating** animal.
- **Habitat:** tropical forests, bamboo forests, limestone (karst) forests, coniferous forests, etc.
- **Distribution:** Southern Nepal, **North-Eastern India**, Bhutan, Bangladesh, Myanmar, northern Indochina, southern China, including the island of Hainan, and most of Taiwan
- **Threats:** it is trafficked for its meat, and its scales are used in traditional medicines.
- **Conservation Status:**
  - ✓ **IUCN Red Lists Status:** Critically Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Pangolins

- Pangolins are **scaly anteater mammals**.
- They have large, **protective keratin scales** covering their skin.
- **Out of the 8 species** of pangolin, **Indian Pangolin & Chinese Pangolin** are found in **India**.
- **Pangolins are the most illegally traded wild mammal on the planet**.

Difference Between Chinese & Indian Pangolins

Indian Pangolin	Chinese Pangolin
Bigger Scales	Smaller scales
Terminal Scale is present	Terminal Scale is absent.
Weight goes from 1.5 kg to 1.8 kg	Weight is roughly 500 to 700 grams.
IUCN Status: Endangered	**IUCN: Critically Endangered**

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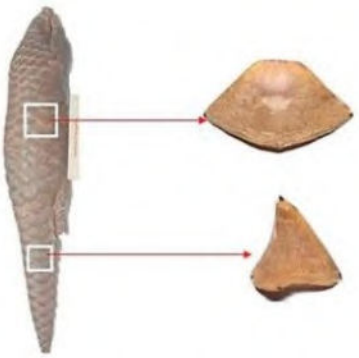
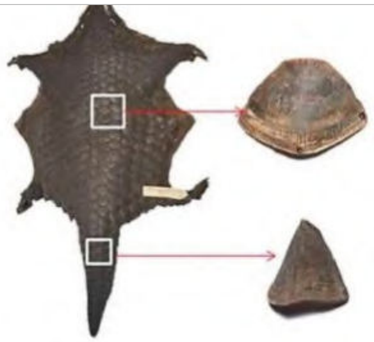

Indian Pangolin


Chinese Pangolin

Mammals – CR – Himalayan Brown/Red Bear

- It is a **subspecies of the brown bear**.
- **Habitat:** forest, shrubland, grassland, wetlands (inland), desert, artificial/terrestrial.
- These bears are omnivorous & **hibernate in a den during the winter**.
- **Distribution:** Nepal, Tibet, north India, and north Pakistan.

- **Threats:** Loss of suitable habitat, persecution by humans, poached for their fur and claws for ornamental purposes & for medicinal use.
- While the **brown bear** as a species is classified as **Least Concern (IUCN),** this **subspecies is highly endangered,** and populations are dwindling.
- **Conservation Status:**
  - **IUCN Red List Status: Critically Endangered**
  - **WPA: Schedule I**
  - **CITES:** Appendix I

Mammals – CR – Kashmir stag/hangul

- **Hangul or Kashmir Stag (CR)** is the only surviving subspecies of **Elk** which is native to **Kashmir (Dachigam National Park)**.

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- **Habitat:** Dense riverine forests, high valleys, and mountains of the Kashmir valley and northern Chamba in Himachal Pradesh.

- **It was the state animal of erstwhile Jammu and Kashmir**.
- It is listed under **the Species Recovery Programme**.
- **Threat:** Habitat destruction, over-grazing by domestic livestock, and poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – CR – Large Rock Rat or Elvira Rat

- **Elvira rat (CR)** is a medium-sized, nocturnal and burrowing rodent **endemic to India**.
- **Habitat:** Tropical dry deciduous shrub land forest, seen in rocky areas.
- **Distribution:** Known only from **Eastern Ghats (600m+) of Tamil Nadu**.

- **Threats:** Major threats are habitat loss, conversion of forests and fuelwood collection.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule V**

Mammals – CR – Malabar Civet

- **Malabar Civet (CR)** is **endemic to India** and was first reported from **Travancore, Kerala**.
- It is nocturnal in nature.
- **Habitat:** Wooded plains and hill slopes of evergreen rainforests.
- **Distribution:** Found exclusively in the **Western Ghats**.

- **Threats:** Deforestation and commercial plantations are major threats.

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- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES**: Appendix III

Mammals – CR – Namdapha Flying Squirrel

- It is a unique (the only one in its genus) flying squirrel that is restricted to a **single valley in the Namdapha NP in Arunachal Pradesh**.
- All flying squirrels are nocturnal.
- **Habitat:** Tropical forest.
- **Distribution:** Found only in **Namdapha Tiger Reserve in Arunachal Pradesh**.

- **Threats:** Hunted for food.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule II**

Flying Squirrel

- Flying squirrels do not really fly.
- They jump from high in the trees and glide through the air like a kite.
- Flying squirrels are a tribe of 44 species of squirrels.
- Their conservation status varies from Near Threatened to Critically Endangered.
- **Indian giant flying squirrel** is included under **'Least Concerned'**.

Q. Consider the following:

1) Black-necked crane
2) Cheetah
3) Flying squirrel
4) Snow leopard

Which of the above are naturally found in India?

a) 1, 2 and 3 only
b) 1, 3 and 4 only
c) 2 and 4 only

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d) 1, 2, 3 and 4

Explanation:

- **Black-necked crane** is commonly found in **Tibetan and trans-Himalayan region**. In winters they **migrate to less colder regions of Indian Himalayas**.
- **Cheetah** is an **extinct species**. They have gone extinct during pre-independence era. Reason: They were hunted down by various Indian kings and the British officers.
- Flying Squirrels are found in many Indian forests.
- **Snow leopard** is an 'endangered' species **found in the Himalayan ranges**.

Answer: b) 1, 3 and 4 only

36.7.2. Mammals – Endangered (EN)

Mammals – EN – Asiatic Lion (*Panthera Leo Leo.*)

- The population of Asiatic Lions are surviving today **only in India**.
- **Habitat:** Tropical and subtropical dry broadleaf forests, thorny forest and savanna.
- **Distribution:** Its range is restricted to **Gir National Park** & the surrounding areas.
- The **Asiatic Lion Reintroduction Project** to find an alternative habitat for reintroducing Asiatic lions was pursued in the early 1990s. But it was not fruitful due to various issues.
  - ✓ **Kuno Wildlife Sanctuary (MP): found most suitable** for reintroduction of **Asiatic Lion** and **Cheetah**. The project never took off due to a lack of cooperation from the MP state government.
  - ✓ **Sita Mata Wildlife Sanctuary (Rajasthan): hotly explored after Kuno**, rejected due to inadequate prey population.
- **Threats:** Habitat destruction, Diseases spreading from domestic animals.
- **Conservation Status:**
  - ✓ **IUCN Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – EN – Bengal Tiger (*Panthera tigris ssp. tigris*)

- **Bengal Tiger** is the **national animal** of both **India & Bangladesh.**
- **Habitat:** Tropical moist evergreen forests, tropical dry forests, tropical & subtropical moist deciduous forests, mangroves, subtropical and temperate upland forests, and alluvial grasslands.
- **Distribution:** Sivaliks–Gangetic flood plain landscape, Central Indian highlands, Eastern & Western Ghats, Sundarbans NP.
- The tigers in the Sundarbans are the only ones in the world **inhabiting mangrove forests.**
- **Ranthambore National Park** hosts India's **westernmost tiger population.**
- **Threats:** Threatened by poaching, loss, and fragmentation of habitat.
- **Conservation Status:**
  - **IUCN Red List Status:** Endangered
  - **WPA: Schedule I**
  - **CITES:** Appendix I

Mammals – EN – Capped Langur

- **Capped langur** is an arboreal species.

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- **Habitat**: Its natural habitat is subtropical or tropical dry forests.
- **Distribution:** It is native to Bangladesh, Bhutan, India, and Myanmar.
- **Threats:** Habitat Loss & Fragmentation
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – EN – Dhole/Asiatic Wild Dog/Indian Wild Dog

- The **Dhole/Indian Wild Dog (EN)** is a highly social animal living in large clans without rigid hierarchies.
- It plays an important role as the **apex predator** in forest ecosystems.
- **Distribution:** They occur in most of India south of the Ganges, particularly in the Central Indian Highlands and the Western and Eastern Ghats of the southern states.
- In **North-East India**, they inhabit Arunachal Pradesh, Assam, Meghalaya, and West Bengal.

- **Threats:** Habitat loss, depletion of its prey base, competition from other predators, persecution and possibly diseases from domestic and feral dogs.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule II**
  - ✓ **CITES:** Appendix II

Mammals – EN – Golden langur

- **Golden Langur** is an old-world monkey.
- **Distribution:** small region of **Manas National Park** and the neighbouring foothills of **Bhutan.**

- **Threats:** Deforestation, human encroachments.

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- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – EN – Hispid hare / Assam rabbit

- **Hispid hare or Assam Rabbit** is native to **South Asia**.
- **Habitat:** Southern foothills of the central Himalayas.

- **Threats:** The habitat of hispid hares is highly fragmented due to increasing agriculture, flood control, and human development.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – EN – Hog deer

- **Hog deer or Pada** are **great swimmers**.
- **Habitat: Terai region** and grasslands in northern India.

- **Threats:** Hunting, habitat loss, habitat fragmentation, human encroachments.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule III**
  - ✓ **CITES:** Appendix I

Mammals – EN – Kondana Rat (Millardia kondana)

- Kondana Rat is a **nocturnal** burrowing rodent that is **found only in India.**

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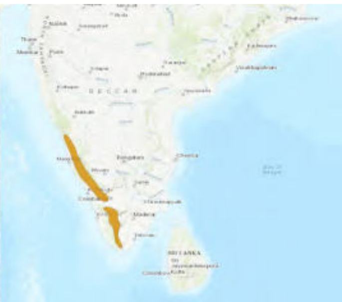
- **Distribution:** Known only from the small **Sinhagarh Plateau**, near **Pune (Maharashtra)**.
- **Habitat:** Tropical and subtropical dry deciduous forests and tropical scrub.
- **Threats:** habitat loss, overgrazing of vegetation and disturbance from tourism and recreational activities.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule V**

Mammals – EN – Lion-tailed macaque/Wanderoo



- **Lion Tailed Macaque** is **endemic to the Western Ghats**.
- Avoids human presence, and do not live, feed, or travel through plantations.
- **Habitat:** Evergreen forests in the Western Ghats range.
- **Threat:** Habitat fragmentation due to spread of agriculture and tea, coffee, teak and cinchona, construction of water reservoirs and human settlements to support such activities.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Q. In which of the following States is lion-tailed macaque found in its natural habitat?

1) Tamil Nadu
2) Kerala
3) Karnataka
4) Andhra Pradesh

Select the correct answer using the codes given below.

a) 1, 2 and 3 only
b) 2 only
c) 1, 3 and 4 only
d) 1, 2, 3 and 4

Explanation:

- Lion-tailed macaque is found in Western Ghats. So, AP is the odd option.

Answer: a) 1, 2 and 3 only

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Mammals – EN – Nilgiri Tahr

- **Nilgiri tahr** is the largest of 3 Tahr species.
- **Habitat:** It inhabits **montane grasslands**.
- **Distribution:** It is endemic to **Nilgiri Hills** & the southern portion of the **Western and Eastern Ghats** in the states of **Tamil Nadu & Kerala**.
- It is the **state animal of Tamil Nadu**.

- **Threats:** Habitat loss, overgrazing, illegal hunting.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**

Mammals – EN – Pygmy Hog

- **Pygmy Hog** is the world's **smallest wild pig**. This species constructs a nest throughout the year.
- It is one of the most useful **environment indicators** of the management status of **grassland habitats**.
- **Habitat:** Relatively undisturbed, tall **terai grasslands**.
- **Distribution:** Previously spread across India, Nepal, and Bhutan. Now only found in Assam **(Manas Wildlife Sanctuary and its buffer reserves)**.
- **Pygmy hog-sucking Louse**, a **parasite** that feeds only on Pygmy Hogs, will also fall in the same risk category of endangered as its survival is linked to that of the host species.

- **Threats:** The main threats are **loss and degradation of grasslands**, dry season burning, livestock grazing and afforestation of grasslands. Hunting is also a threat.
- They are reintroduced into the wild under the **Pygmy Hog Conservation Programme (PHCP).**
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – EN – Red Panda

- **The red panda** is endemic to the **temperate forests of the Himalayas**.
- It is the **State animal** of **Sikkim**.
- **Habitat:** Temperate forests of the Himalayas — Nepal, Bhutan, India, China and Myanmar.
- **Distribution:** Arunachal Pradesh, Meghalaya, Sikkim, and West Bengal.
- **India** (5,000-6,000 red pandas) has the **2nd largest population** after China (6,000-7,000).

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- **Threats:** Habitat loss and fragmentation, poaching, and **inbreeding depression**.
- **Conservation Status:**
  - ✓ **IUCN Red List Status: Endangered**
  - ✓ **WPA: Schedule I**
  - ✓ **CITES: Appendix I**

Mammals – EN – Sangai (Eld's deer subspecies found only in Manipur)

- **Sangai** is **subspecies of Eld's Deer (found in South-East Asia)** found **only in Manipur**.
- It is the state animal of **Manipur**.
- It is also known as **dancing deer**.
- **Distribution: floating marshy grasslands (Phumdi)** of **Keibul Lamjao National Park (KLNP)** located in the southern parts of the **Loktak Lake, Manipur**.

- **Threats:** Overgrazing, loss of grassland habitat.
- **Conservation Status:**
  - **IUCN Red List Status:** Endangered
  - **WPA: Schedule I**
  - **CITES:** Appendix I

Mammals – EN – Western Hoolock Gibbon

- It is the **only ape found in India**.
- **Distribution:** Found south of **Brahmaputra** & North Bank areas and east of the **Dibang (Sikang) Rivers**.
- Its range extends into **7 North-Eastern states**.
- They are divided into **two major species,** i.e., **Western Hoolock Gibbon (found in NE India)** & **Eastern Hoolock Gibbon (Myanmar)**.
- Both Hoolock Gibbon species are separated by the **Chindwin River (a tributary of Irrawaddy)**.
- **Conservation Status:**

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- ✓ **IUCN Red List Status:** Endangered
- ✓ **WPA: Schedule I**
- ✓ **CITES:** Appendix I

Mammals – EN – White-bellied Musk Deer

- White-bellied musk deer are very well adapted for **high altitudes**.
- **Habitat:** Kashmir, Kumaon and Sikkim.

- **Threat:** Poaching & illegal trade for its musk. Only males produce the musk.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – EN – Wild Water Buffalo

- **Wild Water Buffalo** is a large bovine native to the Indian subcontinent & Southeast Asia.
- **Habitat:** Wet grasslands, swamps, flood plains & densely vegetated river valleys.
- **Distribution:** Around Kaziranga, Manas & Dibru-Saikhowa NP, Laokhowa Wildlife Sanctuary & Bura Chapori Wildlife Sanctuary & around D'Ering Memorial Wildlife Sanctuary in Arunachal Pradesh.

- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **CITES:** Appendix III

36.7.3. Mammals – Vulnerable (VU)

Mammals – VU – Barasingha or swamp deer

- Barasingha **(twelve horned)** is the state animal of **Madhya Pradesh**.
- In MP, it is found exclusively in **Kanha Tiger Reserve**.
- **Habitat**: Isolated localities in Northern & Central India, and Southwestern Nepal.

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- **Threats:** Hunting for horns, habitat fragmentation and habitat loss.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

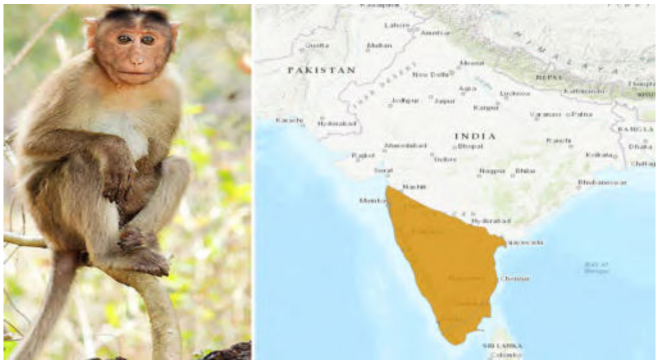
Mammals – VU – Black panther

- **Black Panther** is the melanistic colour variant of the leopard & jaguar.
- **Habitat:** Tropical Forests
- **Distribution:** India, Sri Lanka, Nepal, Thailand, Peninsular Malaysia & Java, and black jaguars in Mexico, Panama, Costa Rica and Paraguay

- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – VU – Bonnet macaque

- **Bonnet macaque** is a species of macaque **endemic to southern India**.



- **Distribution:** distribution is limited by the Indian Ocean on three sides, and the Godavari and Tapti Rivers
- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**

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- ✓ **IUCN Red List Status:** Vulnerable
- ✓ **WPA: Schedule II**
- ✓ **CITES:** Appendix II

Mammals – VU – Clouded leopard

- **Clouded leopard** is the state animal of **Meghalaya**.
- **Dampa Tiger Reserve** had one of the **highest** population densities of clouded leopards.
- It is included under **the Species Recovery Programme.**
- **Habitat:** Grassland, shrubs, subtropical and dense tropical forest up to a height of 7,000 feet occurring from the Himalayan foothills through mainland Southeast Asia into China.
- **Distribution:** WB, Sikkim, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.

- **Threat:** deforestation and poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – VU – Dugong (Sea Cow)

- Dugongs are **herbivorous marine mammals**.
- Dugong belongs to **Manatees species** (large, fully aquatic, primarily herbivorous marine mammals).
- **Habit:** A few hundred surviving in the **Gulf of Mannar, Andaman and Nicobar Islands & Gulf of Kutch**.
- Dugongs once inhabited waters off the **Odisha, WB and AP**. But they are **extinct in these areas now**.
- It is included in **Convention on Migratory Species (CMS) list**.

- **Threats: Loss of seagrass beds** due to ocean floor trawling, pollution, unsustainable hunting or poaching.
- **Conservation Status:**
  - **IUCN Red List Status:** Vulnerable
  - **WPA: Schedule I**
  - **CITES:** Appendix I

Q. With reference to 'dugong', a mammal found in India, which of the following statements is/are correct?

1) It is an herbivorous marine animal.
2) It is found along the entire coast of India.
3) It is given legal protection under Schedule 1 of the Wildlife (Protection) Act, 1972.

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Select the correct answer using the code given below.

a) 1 and 2
b) 2 only
c) 1 and 3
d) 3 only

Explanation:

- Dugong is an herbivorous animal. It eats sea grass and aquatic plants found in shallow oceans (at depths sea grass and aquatic plants do not grow due to absence of sunlight).
- Dugongs once inhabited waters off the **Odisha, WB and AP**. But they are **extinct in these areas now**.

Answer: c) 1 and 3

Mammals – VU – Eastern Hoolock Gibbon

- **Distribution in India:** a small region between **Nao-Dehing, Lohit** & **Dibang rivers** in **Arunachal Pradesh (Namdapha National Park).**

- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – VU – Four-horned antelope/Chousingha

- The four-horned antelope must **drink water regularly** in order to survive.

- **Distribution:** Presently, it is **confined to the Indian subcontinent**, scattered between the foothills of the Himalayas in the north to the Deccan Plateau in the south. **Gir National Park** has 1000 of these animals.
- **Threats:** Loss of its natural habitat due to agricultural expansion. Four-horned skull and horns have made it a popular target for hunters.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix III

Mammals – VU – Gaur/Indian Bison

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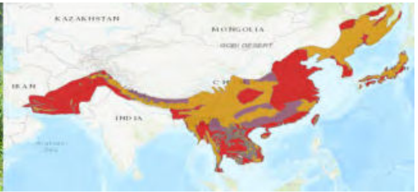
- **Indian bison** is a large bovine native to **South Asia & Southeast Asia**.
- The **domesticated form** of the gaur is called **Gayal or Mithun.**
- **Trishna Wildlife Sanctuary in Tripura** is the country's **only natural breeding centre** of **Bisons**.
- **Habitat:** evergreen forests, semi-evergreen, and deciduous forests of South and Southeast Asia.
- **Distribution:** In India, they are found in **Nagarhole, Bandipur, Masinagudi National Parks**.

- **Threats:** Poaching for trade to supply international markets & commercial trade in meat and trophies
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – VU – Himalayan Black Bear (Ursus thibetanus)

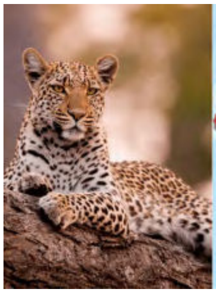
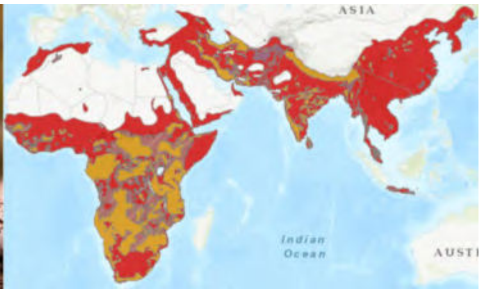
- The Himalayan black bear is also known as Asiatic black bear or White-Chested Bear.
- **Habitat: Himalayan forests**, **North East India**, South East Asia, South-East China.



- **Threats:** Forest degradation, bamboo plantations, poaching for its body parts, which are used in traditional medicine
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule II**
  - ✓ **CITES:** Appendix I

Mammals – VU – Leopard (*Panthera pardus*)

- The Indian leopard is a leopard subspecies widely distributed on the Indian subcontinent.
- **Habitat:** It inhabits foremost savanna and rainforest and areas where grasslands, woodlands, and riverine forests remain largely undisturbed.
- **Distribution:** Indian subspecies is found in **all forested habitats** in the country.
- It is **absent only in arid deserts & above timberline in the Himalayas**.

- **Threat:** hunting, poaching, habitat loss, depletion of natural prey, human conflict.
- **State wise Leopard population:**

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- ✓ **MP: 3421 MP is (Highest in both Tiger & Leopard)**.
- ✓ **Karnataka: 1783**
- ✓ **MH: 1690**
- ✓ **Central India has the highest number of leopards, followed by the Eastern Ghats.**

- **Rajasthan** is the 1st state to launch **Project Leopard**.
- **Conservation Measures:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA**: **Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – VU – Mainland Serow

- The Mainland Serow is a serow species native to the Himalayas, Southeast Asia and China.
- There are several species of serows & all of them are **found in Asia.**
- **Habitat:** Himalayan region — typically found at altitudes between 2,000 m & 4,000 m.

- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Himalayan Serow

- It is a **subspecies** of the **Mainland Serow.**
- It resembles a cross between a goat, a donkey, a cow, and a pig.
- State Animal of **Mizoram**.
- It is restricted to the **Himalayan region** & found at altitudes between **2,000 m & 4,000 m.**

Mammals – VU – Nilgiri Langur/ Nilgiri Leaf Monkey

- Nilgiri langur is a type of old-world monkey found in the **Nilgiri Hills.**
- **Habitat: Hilly areas of Western Ghats** in **Karnataka. Tamil Nadu & Kerala.**

- **Threats:** Habitat degradation, development activities, introduction of exotic tree species.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA**: **Schedule I**
  - ✓ **CITES:** Appendix II

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Mammals – VU – Nilgiri Marten

- Nilgiri marten is the only marten species native to **southern India**.
- **Distribution: Endemic to the Western Ghats**. Inhabits areas that are far from human disturbance.

- **Threat:** habitat loss and fragmentation, hunting for its fur.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule II**
  - ✓ **CITES:** Appendix III

Mammals – VU – Oriental small-clawed otter/Asian small-clawed otter

- **Asian Small Clawed Otter** are **semiaquatic mammals** that feed on fish, amphibians, birds and small mammals.
- It is the **smallest otter** species in the world.

- **Habitat:** It lives in **mangrove swamps** and **freshwater wetlands**.
- **Threat:** habitat loss, pollution and hunting.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – VU – Smooth-coated otter

- **Habitat:** Eastern parts of India and South-East Asia.

- **Threats:** loss of wetland habitats, reclamation of wetlands for agriculture, poaching, etc.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule II**
  - ✓ **CITES:** Appendix I

Mammals – VU – Snow Leopard

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- A snow leopard (also known as **Ghost of the Mountains**) is both a **Keystone & Indicator Species** of the health of their high-altitude habitat.
- **Habitat:** It inhabits **alpine & subalpine zones** at elevations from 3,000 to 4,500 m.
- **Distribution:** In India, their range encompasses a large part of the **western Himalayas,** including the states of **Jammu & Kashmir**, **Himachal Pradesh**, **Uttarakhand & Sikkim** & **Arunachal Pradesh** in the eastern Himalayas.

- **Threats:** Human interference, competition with livestock, poaching, climate change, unregulated tourism, illegal trade, infrastructure development in the mountains, and excessive livestock grazing.
- The government has identified it as a **flagship species for the high-altitude Himalayan ecosystem**.
- The snow leopard is also included in **Species Recovery Programme**.
- **Conservation Status:**
  - ✓ **IUCN Red List** – Vulnerable
  - ✓ **WPA – Schedule I**
  - ✓ **CITES** – Appendix I

Mammals – VU – Stump Tailed Macaque

- **Stump Tailed Macaque** is native to the North-Eastern part of India & South East Asia.
- **Habitat:** Generally found in evergreen tropical and subtropical moist broadleaf forests, at different elevations depending on the amount of rainfall in the area
- **Distribution:** Its range in India extends from Assam and Meghalaya to eastern Arunachal Pradesh, Nagaland, Manipur, Mizoram and Tripura
- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule II**
  - ✓ **CITES:** Appendix II

Mammals – VU – Takin

- Takin is also known as **Cattle chamois or Gnu Goat**.
- **Distribution:** Mountainous regions in the **Eastern Himalayan Mountains** & western China.

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- **Threats:** Largely due to overhunting and the destruction of their natural habitat, the takin is considered Endangered in China and Vulnerable as per the IUCN.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix II

36.7.4. Mammals – Near Threatened

Mammals – NT – Assamese macaques

- **Assamese Macaque** belongs to an Old World monkey family native to **South & Southeast Asia**.

- **Distribution: Eastern Assamese macaque** in Bhutan & NE India & **Western Assamese Macaque** in Uttar Pradesh, Sikkim, Assam and northernmost West Bengal in northern India.
- **Threats:** It includes selective logging and various forms of anthropogenic development and activities, alien invasive, hunting and trapping for sport, medicine, food, and the pet trade.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Near Threatened
  - ✓ **WPA: Schedule II**
  - ✓ **CITES:** Appendix II

Mammals – NT – Chiru/Tibetan Antelope

- Tibetan antelope is a bovid native to the **Tibetan plateau**.
- **Habitat:** Inhabits open alpine and cold steppe environments.

- **Threat:** The chiru is threatened by hunting for its fine wool, which is used to make the **shahtoosh** scarves, meat, magnificent horns.

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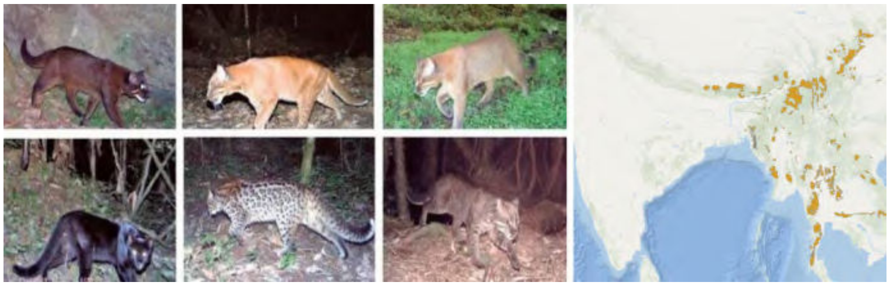
- Its prime habitats have been declared as Wildlife Sanctuaries viz. **Karakoram Wildlife Sanctuary** & **Changthang Cold Desert Wildlife Sanctuary (Ladakh).**
- **Conservation Status:**
  - **IUCN Red List Status:** Near Threatened
  - **WPA: Schedule I**
  - **CITES:** Appendix I

Mammals – NT – Golden cat

- **Asiatic golden cat** comes in five other shades in Arunachal Pradesh, scientists have discovered.
- **Habitat:** It is found across eastern Nepal through **north-eastern India** to Indonesia.
- **Threats:** Deforestation, declining prey base and hunting for the illegal wildlife trade.



- **Conservation Status:**
  - **IUCN Red List status:** Near Threatened
  - **WPA: Schedule I**
  - **CITES:** Appendix I

Mammals – NT – Grizzled Giant Squirrel

- **Habitat: Western Ghats** and hills of Sri Lanka.
- Nests of Grizzled Giant Squirrel are spotted near **Pakkamalai Reserve Forests (Eastern Ghats, TN)**.
- **Distribution:** In India, the species is usually known to nest only in the **Western Ghats.**

- **Threats:** Habitat loss and poaching.
- **Conservation Status**
  - ✓ **IUCN Red List Status:** Near Threatened
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix II

Mammals – NT – Himalayan Goral

- **Himalayan Goral** is a bovid species found across the Himalayas
- **Habitat:** Inhabit most of the southern slopes of the Himalayas from Jammu and Kashmir to eastern Arunachal Pradesh

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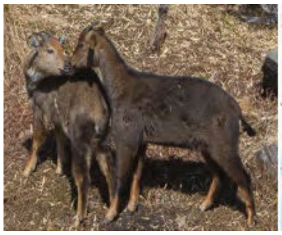
- **Distribution:** Including Bhutan, northern India including Sikkim and Arunachal Pradesh, Nepal, southern Tibet, and possibly western Myanmar.



- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Near Threatened
  - ✓ **WPA: Schedule III**
  - ✓ **CITES:** Appendix I

Mammals – NT – Himalayan Tahr

- The Himalayan tahr is a relative of the wild goat.
- **Habitat:** Adapted to life on the rugged mountain slopes of the Himalayas, extending from the montane to alpine zones.

- **Threats:** uncontrolled hunting and deforestation. There is significant competition with livestock for summer grazing in some areas.
- **Conservation Status:**
  - **IUCN Red List Status:** Near Threatened
  - **WPA: Schedule I**

Mammals – NT – Indian Wild Ass/ Khur

- Indian Wild Ass is a subspecies of the onager native to Southern Asia.
- **Distribution:** Mostly occurs in the **Rann of Kutch** region.
- The population steadily increasing.
- Today, its last refuge lies in the **Indian Wild Ass Sanctuary, Little Rann of Kutch**.

- **Threats:** Diseases, habitat degradation due to salt activities, Invasive species **Prosopis juliflora shrub**, and encroachment and grazing by the **Maldharis**.
- **Conservation Status:**
  - **IUCN Red List Status:** Near Threatened
  - **WPA: Schedule I**

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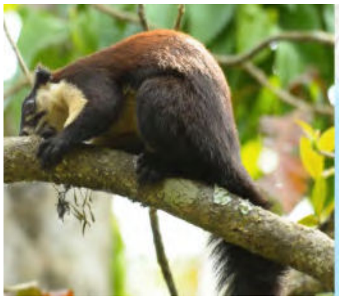
- **CITES:** Appendix I

Mammals – NT – Malayan Giant Squirrel

- The Malayan Giant Squirrel is **one of the world's largest squirrel species**.
- **Habitat:** evergreen and semi-evergreen forests, from plains to hills at elevations of 50 m to 1,500 m.
- **Distribution:** In parts of the **North-Eastern States** and **South-East Asia**.



- **Threats:** Deforestation, Fragmentation of forests, Crop cultivation and Over-harvesting of food.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Near Threatened
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix II

Mammals – NT – Marbled cat

- Marbled cat is in size to a domestic cat but has rounded ears and a very long tail that is as long as the cat's head and body.
- **Habitat:** northern India (Sikkim, Darjeeling) and Nepal, through south-eastern Asia to Borneo and Sumatra.

- **Threats:** Hunting, habitat destruction for marbled cat and its prey.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Near Threatened
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Mammals – NT – Markhor

- The Markhor is the **national animal of Pakistan.**
- **Habitat:** Mountains of central Asia and Jammu and Kashmir .

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- **Threats:** Hunting (both for meat and for its twisted horns), armed conflict and habitat loss.
- **Conservation Status:**
  - **IUCN Red List Status:** Near Threatened
  - **WPA: Schedule I**
  - **CITES:** Appendix I

Mammals – NT – Rusty-Spotted Cat

- **Rusty Spotted Cat** occurs mainly in moist and dry deciduous forests but is likely absent in evergreen forest.
- It prefers dense vegetation & rocky areas.
- **Distribution:** Eastern Gujarat Gir National Park in Maharashtra Tadoba-Andhari Tiger Reserve & along India's Eastern Ghats.

- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Near Threatened
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

36.7.5. Mammals – Least Concern (LC)

Mammals – LC – Asian palm civet

- **Asian Palm Civet** is also known as common palm civet or toddy cat.
- **Habitat:** It inhabits primary forests but also occurs at lower densities in secondary and selectively logged forests.
- **Distribution:** Native to India, Nepal, Bangladesh, Bhutan, Myanmar, Sri Lanka & South East Asia.

- **Threats:** Threatened by poaching and illegal wildlife trade, buyers use it for the increasing production of kopi luwak.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule II**
  - ✓ **CITES:** Schedule III

Mammals – LC – Barking deer

- **Barking deer** is also known as **Indian Muntjac,** calls sound like barking, often when frightened by a predator.

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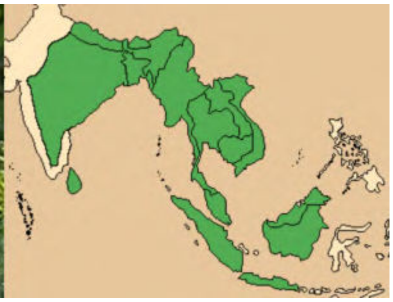
- **Habitat:** It is found in tropical & subtropical deciduous forests, grasslands, savannas & slopes of the Himalayas.
- **Distribution:** It is endemic to South and South East Asia like Bangladesh, China, N-E India, Vietnam, Malay Peninsula etc.



- **Threats:** It is hunted for sport and for their meat and skin.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule III**

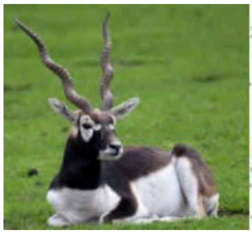
Mammals – LC – Bharal

- **Bharal,** also called the **blue sheep,** is a caprine native to the high Himalayas.
- **Distribution:** it occurs in India, Bhutan, China (in Gansu, Ningxia, Sichuan, Tibet, and Inner Mongolia), Myanmar, Nepal, and Pakistan.

- **Threats:** poaching for meat and competition with livestock.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix III

Mammals – LC – Blackbuck/Indian Antelope

- **Blackbuck** is an antelope native to **India & Nepal.**
- It is known locally as **Krushnasara Mruga**.
- **Habitat: Grassy plains** and lightly **forested areas** with **perennial water sources**.
- **Distribution:** In the Indian subcontinent, the blackbuck can also be found in deserts (in the northwestern region), coastal areas, mountains (in the northern-north-eastern region)



- **Threat:** excessive hunting for meat and sporting trophies, as well as habitat loss.

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- **Associations with the Indian culture:**
  - ✓ It had been a source of food in the **Indus Valley civilisation** (3300–1700 BCE).
  - ✓ **Bone remains** have been discovered in sites such as **Dholavira** & **Mehrgarh.**
  - ✓ It is routinely depicted in **miniature paintings of the Mughal Era** (16th to 19th centuries).
  - ✓ Tribes such as the **Bishnois revere the blackbuck**.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix III

Mammals – LC – Caracal Cat

- Caracal Cat is medium-sized wild cat.
- **Habitat:** Forests, savannas, marshy lowlands, semi-deserts & scrub forests, but prefers dry areas with low rainfall and availability of cover
- **Distribution:** Western India (found in parts of Rajasthan & Gujarat).
- **It was recently added to the Species Recovery Programme of Integrated Development of Wildlife Habitats (IDWH)**.

- **Conservation Status:**
  - ✓ **IUCN Red List Status: Least Concern**
  - ✓ **WPA: Schedule I**
  - **CITES: Appendix I**

Mammals – LC – Common mongoose

- **Common Mongoose** is a **State Animal of Chandigarh.**
- **Habitat:** It inhabits open forests, scrublands and cultivated fields, often close to human habitation.
- **Distribution:** It is native to the Indian subcontinent and West Asia.

- **Threats:** Habitat loss & fragmentation
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule II**

Mammals – LC – Golden jackal

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- **Golden Jackal** is native to Southeast Europe, Southwest Asia, South Asia & regions of Southeast Asia.

- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule III**
  - ✓ **CITES:** Appendix III

Mammals – LC – Indian Flying Fox (Greater Indian Fruit Bat)

- **Greater Indian Fruit Bat** is the **largest flying bat in India**.
- It can transmit **several viruses** to humans like **Nipah Virus**.
- It is **nocturnal & feeds mainly on ripe fruits**, such as mangoes & bananas, & nectar.
- **Habitat:** Found across the Indian Subcontinent.

- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule IV**
  - ✓ **CITES:** Appendix II

Mammals – LC – Mouse Deer

- **Mouse deer** is found in forests in South & Southeast Asia & in the rainforests of Central & West Africa.

- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule I**

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Mammals – LC – Nilgai (Blue Bull)

- **Nilgai** is the largest Asian antelope & is ubiquitous across the northern Indian subcontinent.
- **Habitat:** Bushes and scattered trees in scrub forests and grassy plains.

- **Distribution:** Indravati National Park (Chhattisgarh) & Pench Tiger Reserve (Madhya Pradesh), Ranthambhore National Park & Keoladeo National Park (both in Rajasthan).
- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule III**
  - ✓ **CITES:** Appendix III

Mammals – LC – Rhesus monkeys

- **Rhesus Monkey** is a species of Old World monkey.
- **Habitat:** Found in grasslands, woodlands & in mountainous regions up to 2,500 m (8,200 ft) in elevation.
- **Distribution:** It is native to South, Central, and Southeast Asia.

- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule II**
  - ✓ **CITES:** Appendix II

Mammals – LC – Small Indian Civet

- **Small Indian Civet** native to South and Southeast Asia.
- **Distribution:** In most of India, Sri Lanka, Myanmar, Thailand, Laos, Cambodia, Vietnam, south and central China, and Taiwan

- **Threats:** It is hunted for its meat, skin & used in medicine.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern

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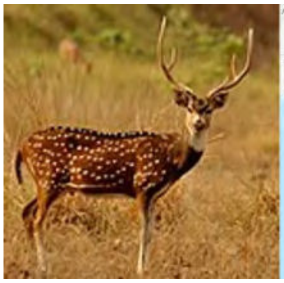
- ✓ **WPA: Schedule II**
- ✓ **CITES:** Appendix III

Mammals – LC – Spotted Deer (Chital)

- **Chital** is a species of deer that is native to the Indian subcontinent.
- **Distribution:** Eastern Rajasthan and Gujarat, Bhabar-terai belt of the foothills of the Himalaya, Uttar Pradesh & Uttaranchal through to Nepal, northern West Bengal and Sikkim & Assam.
- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concerned
  - ✓ **WPA: Schedule III**



Mammals – LC – Travancore flying squirrel

- **Travancore flying squirrel** is also known as the **small flying squirrel.**
- **Distribution:** They were thought to be extinct but were rediscovered in 1989 after a gap of 100 years in Kerala.

- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule I**

Mammals – LC – Wild Boar

- **Wild Boar** also known as the **Wild Swine** or **Common Wild Pig.**
- **Habitat:** It inhabits a diverse array of habitats from boreal taigas to deserts. In mountainous regions, it can even occupy alpine zones.
- **Distribution:** Native to much of Eurasia and North Africa, and has been introduced to the Americas and Oceania.

- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**

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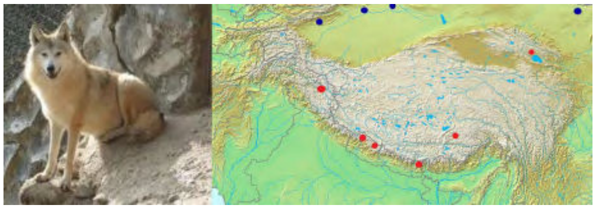
- ✓ **IUCN Red List Status:** Least Concern
- ✓ **WPA: Schedule III**

36.7.6. Mammals – Not Evaluated (NE)

Mammals – NE – Himalayan wolf

- **Distribution:** Trans-Himalayan region of Himachal Pradesh, Jammu and Kashmir.



- **Threats:** Climate Change, prey by humans to protect their cattle.
- **Conservation Status**:
  - **IUCN Red List Status**: 'Not Evaluated'.
  - Several biologists feel that it needs to be in the 'Critically Endangered List'.

36.7.7. Birds – Critically Endangered (CR)

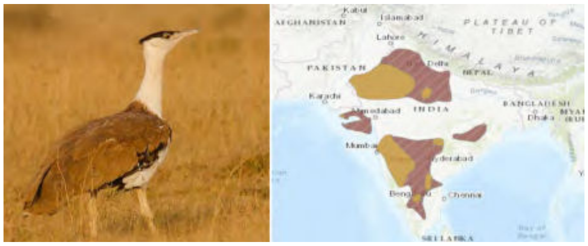
Birds – CR – Bengal Florican

- **Bengal Florican** is a rare **bustard species** that is very well known for its **mating dance**.
- **Habitat:** Grasslands occasionally interspersed with scrublands.
- **Distribution:** Native to only 3 countries in the world: Cambodia, India and Nepal. In India, it occurs in 3 states, namely Uttar Pradesh, Assam and Arunachal Pradesh.

- **Threats:** Ongoing conversion of the bird's grassland habitat for various purposes, including agriculture, is mainly responsible for its population decline.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Birds – CR – Great Indian Bustard

- The **Great Indian Bustard (CR)** is **one of the heaviest flying birds** in the world.
- It is the **state bird of Rajasthan**.



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- **Habitat:** large expanses of **dry grassland & scrub**.
- Its largest populations (95%) are found in the Indian state of **Rajasthan (Jaisalmer)**.
- Today, its population is confined mostly to **Rajasthan & Gujarat**.
- A small population also occurs in **Maharashtra, Karnataka & Andhra Pradesh**.
- **Threats:** Habitat loss, hunting, mortality due to collision with power lines (they have a poor frontal vision); Great Indian Bustards fly across to Pakistan' desert from Rajasthan & fall prey to poachers.
- **Conservation Status:**
  - ✓ **IUCN Red List Status: Critically Endangered**
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Birds – CR – Himalayan Quail

- **Himalayan quail** is a bird belonging to the pheasant family, with distinctive red or yellow bill and legs, and prominent white spots around the eyes.
- **Habitat:** Tall grass and scrub on steep hillsides.
- **Distribution:** Western Himalayas.

- **Threats:** Indiscriminate hunting during the colonial period along with habitat modification.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**

Birds – CR – Jerdon's Courser

- **Jerdon's Courser** is a nocturnal bird found **only in the northern part of Andhra Pradesh** in peninsular India (**Sri Lankamaleswara Wildlife Sanctuary**).
- **Habitat:** Undisturbed scrub jungle with open areas.
- **Distribution: Jerdon's Courser is endemic to Andhra Pradesh**.

- **Threats:** Clearing of scrub jungle, creation of new pastures, growing of dryland crops, Illegal trapping of birds, plantations of exotic trees, quarrying and the construction of the river canals.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**

Birds – CR – Pink Headed Duck

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- Pink Headed Duck **males have a deep pink head** and neck from which the bird derives its name.
- **Habitat:** Overgrown still-water pools, marshes and swamps in lowland forests and tall grasslands.
- **Distribution:** Recorded in India, Bangladesh and Myanmar. Maximum records are from northeast India.

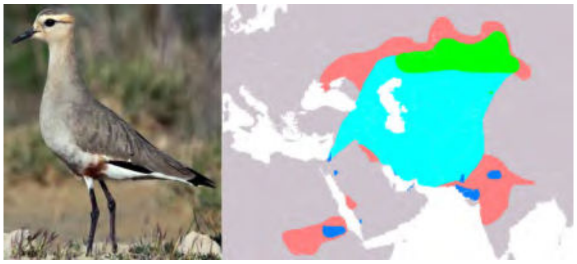
- **Threats:** Wetland degradation and loss of habitat, along with hunting, are the main causes of its decline.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES: Appendix I**

Birds – CR – Siberian Crane

- **Siberian Crane** is a large, strikingly majestic migratory bird that breeds and winters in wetlands.
- They are known to arrive in **winter** at **Keoladeo National Park, Rajasthan**.

- **Habitat:** Wetland areas.
- **Distribution:** Keoladeo National Park in Rajasthan.
- **Threats:** Pesticide pollution, wetland drainage, development of prime habitat into agricultural fields, and to some extent, hunting.
- It is also protected under **Convention on Migratory Species.**
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Birds – CR – Sociable Lapwing



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- **Sociable lapwing** is a **winter migrant** to India.
- **Habitat:** Fallow fields and scrub desert.
- **Distribution:** Central Asia, Asia Minor, Russia, Egypt, India, Pakistan. In India, habitat is restricted to the north and northwest of the country.
- **Threats:** Conversion of habitat to arable land, illegal hunting and proximity to human settlements.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered

Birds – CR – Spoon Billed Sandpiper

- India is home to some of the last existing wintering grounds of Spoon Billed Sandpiper species.
- **Habitat:** Coastal areas with sparse vegetation.
- **Distribution:** Has been recorded along the coastlines of West Bengal, Orissa, Kerala and Tamil Nadu.

- **Threats:** Habitat degradation and land reclamation. Human disturbance also leads to high incidence of nest desertion.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered

Birds – CR – White-bellied Heron

- Also known as the **Imperial heron** is a species of large heron.
- **Distribution:** Extremely rare bird found in five or six sites in Assam and Arunachal Pradesh, one or two sites in Bhutan, and a few in Myanmar.
- **Habitat:** Rivers with sand or gravel bars or inland lakes.

- **Threats:** Loss and degradation of lowland forests and wetlands through direct exploitation and disturbance by humans.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**

36.7.8. Birds – Endangered (EN)

Birds – EN – Forest Owlet

- Forest Owlet is endemic to the forests of **Central India.**

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- **Habitat:** Dry deciduous forest.
- **Distribution:** South Madhya Pradesh, in north-west Maharashtra and north-central Maharashtra.

- **Threats:** Logging operations, burning and cutting of trees damage roosting and nesting trees of the Forest Owlet.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

36.7.9. Birds – Vulnerable (VU)

Birds – VU – Great Indian Hornbill

- The **Great Hornbill** is the **state bird** of **Kerala** & **Arunachal Pradesh** in India.
- The **Hornbill festival is celebrated in Nagaland**.

- **Habitat:** Rainforest regions of India (**Western Ghats and North eastern** region of India), Southeast Asia.
- **Threats:** Habitat loss and hunting.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Q. In which of the following regions of India are you most likely to come across the `Great Indian Hornbill' in its natural habitat? (2016)

a) Sand deserts of northwest India
b) Higher Himalayas of Jammu and Kashmir
c) Salt marshes of western Gujarat
d) Western Ghats

Answer: d)

Birds – VU – Yellow-Throated Bulbul

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- **Yellow Throated Bulbul** is a species of songbird in the bulbul family of passerine birds.
- **Habitat:** They are found on scrub habitats on steep, rocky hills.
- **Distribution:** It is endemic to southern peninsular India.

- **Threats:** Threatened by granite quarrying.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable

36.7.10. Birds – Near Threatened (NT)

Birds – NT – Black Necked Crane (Grus nigricollis)

- **Black Necked Crane** was the **state bird** of erstwhile **Jammu & Kashmir.**

- **Habitat:** The breeding areas are alpine meadows, lakeside and riverine marshes and river valleys. They also make use of barley and wheat fields in these areas.
- **Distribution:** The species breeds on the **Tibetan plateau** & **migrates to Tawang for the winter**.
- The bird, most commonly found in China, is legally protected in Bhutan and India and is **considered sacred** to certain Buddhist traditions.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Near Threatened
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Q. Which one of the following groups of animals belongs to the category of endangered species?

a) Great Indian Bustard, Musk Deer, Red Panda and Asiatic Wild Ass
b) Kashmir Stag, Cheetal, Blue Bull and Great Indian Bustard
c) Snow Leopard, Swamp Deer, Rhesus Monkey and Saras (Crane)
d) Lion-tailed Macaque, Blue Bull, Hanuman Langur and Cheetal

Obsolete question. As of 2019, the status of many of these species has changed.

Birds – NT – Mrs. Hume's Pheasant

- **Hume Pheasant** is also known as Hume's pheasant or the bar-tailed pheasant.
- **Distribution:** Found throughout forested habitats of the Mizoram, Patkai Range, Yunnan & northern parts of Myanmar & Thailand.

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- **Threats:** Fragmented population and being hunted for food.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Near Threatened
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

36.7.11. Birds – Least Concern (LC)

Birds – LC – Amur Falcon

- **Amur Falcon** is **migratory raptor** species.
- **Distribution:** It breeds in South-Eastern Siberia, Mongolia & China before migrating to India & over the Arabian Sea to winter in Southern Africa.
- **Habitats:** Forest, Savanna, Grassland, Wetlands (inland).
- **Nagaland** is also known as the **"Falcon Capital of the World".**
- **Amur Falcon Festival:** Tysro Valley Wildlife Protection Society (NGO) in **Nagaland** celebrates the festival.

- **Threats:** Illegal trapping and killing during migration, loss from agricultural practices and land reclamation, logging & wood harvesting.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule IV**
  - ✓ **CITES:** Appendix II

Birds – LC – Bastar hill myna/Common Hill Myna

- **Common Hill Myna** is also known as talking bird.
- **Distribution:** Kumaon division in India east through Nepal, Sikkim, Bhutan and Arunachal Pradesh, the lower Himalayas, terai and foothills up to 2,000 m ASL.

- **Threats:** Habitat destruction & overexploitation for the pet trade.

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- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix II

Birds – LC – The Himalayan bulbul/white-cheeked bulbul

- Himalayan Bulbul is a species of songbird in the bulbul family found in **Central and South Asia**.

- **Habitat:** Forests and Shrubland, gardens and parks.
- **Distribution:** It is found near **Himalayan Forests.**
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern

36.7.12. Reptiles – Critically Endangered (CR)

Reptiles – CR – Northern River Terrapin/ Four Toed River Terrapin

- The **Northern River Terrapin** is considered extinct in much of its former range.
- It is one of Asia's largest **freshwater & brackish water** turtles.
- **Habitat:** Bangladesh (in the Sundarbans), **West Bengal (Sundarbans)** & parts of Southeast Asia.

- **Threats:** Unsustainable harvesting across the subcontinent & Southeast Asia.
- **Conservation Status:**
  - **IUCN Red List:** Critically Endangered
  - **WPA: Schedule I**
  - **CITES:** Appendix I

36.7.13. Reptiles – Vulnerable (VU)

Reptiles – VU – Star Tortoise

- Indian Star Tortoise is found in dry areas and scrub forests in **India, Pakistan & Sri Lanka.**
- **Habitat:** Eastern parts of India below West Bengal and Gujarat.

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- **Threats: loss of habitat to agriculture**, **illegal harvesting for meat and pet trade** (superstitious people pet them as they believe that the reptile brings prosperity).
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Vulnerable
  - ✓ **WPA: Schedule IV**
  - ✓ **CITES:** Appendix I

What's the difference between turtles and tortoises?

Turtle	Tortoise
• Lives in water	• Lives on land
• Come to land to lay eggs	• Everything happens on land
• Good swimmers	• Bad swimmers
• The majority of them are carnivores, while some are Omnivores and very few are herbivores.	• Herbivores (plant-eating)

- **Terrapins** are almost a **combination of turtles and tortoises**.
- They live in water, primarily small dams or ponds; however, they can also live on land.

Q. Consider the following statements:

1) Some species of turtle are herbivores
2) Some species of fish are herbivores
3) Some species of marine mammals are herbivores
4) Some species of snakes are viviparous

Which of the statement given above are correct?

a) 1 and 3 only
b) 2, 3 and 4 only
c) 2 and 4 only
d) 1, 2, 3 and 4

Explanation:

- Marine mammals like dugong are herbivores.
- Most of the viper snakes and most sea snakes are viviparous (directly give birth to young ones).

Answer: d) all

36.7.14. Reptiles – Near Threatened (NT)

Reptiles – NT – Sispara Day Gecko

- **Distribution:** Sispara Day Gecko is endemic to **Western Ghats**, and found in Sispara, **Nilgiris**, Cochin.

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- **Threats:** Habitat conversion and modification.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Near Threatened

36.7.15. Reptiles – Least Concern (LC)

Reptiles – LC – Golden Gecko

- **Habitat: Golden Gecko** is found among rocks in dark, shady ravines.
- **Distribution:** Found Only in Eastern Ghats of India.

- **Threats:** Habitat loss and fragmentation & poaching.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **WPA: Schedule I**

Reptiles – LC – Tokay Gecko

- **Tokay Gecko** is **nocturnal** species.
- **Habitat:** Rainforest, where it lives on trees and cliffs, and it also frequently adapts to rural human habitations, roaming walls and ceilings at night in search of insect prey.
- **Distribution:** North-East India & South-East Asia.

- **Threats:** used in traditional medicine in South East Asia and China.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Least Concern
  - ✓ **CITES:** Appendix II

36.7.16. Amphibians – Endangered (EN)

Amphibians – EN – Purple frog (Nasikabatrachus sahyadrensis)

- Purple frog is believed to have co-existed with dinosaurs (extinct 65 million years ago).

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- **Distribution:** It is endemic to the southern **Western Ghats (mostly Kerala)**.
- It lives its entire life in tunnels, comes out to the surface once in a year (early rains) to breed and lays eggs.
- The frog's closest relatives were found in Seychelles (proof of the theory of Gondwanaland – amphibians **can't tolerate salinity.** So, it's a possibility that the landmass could have been connected).

- **Threats:** Check dams submerging the perennial breeding grounds, rapid deforestation and conversion of forest land into cropland.
- **Conservation Status:**
    - **IUCN Red List Status:** Endangered

36.7.17. Spiders – Critically Endangered (CR)

Spider – CR - Gooty Tarantula/Metallic Tarantula

- Also known as Peacock Tarantula was first found in **Gooty (Ooty/Udagamandalam).**
- **Habitat:** Wooded mountain area.
- **Distribution:** Endemic to **Nallamala Hills** of **South India.**

- **Threats:** They are one of the most expensive spiders in the illegal pet trade.
- **Conservation Status:**
    - ✓ **IUCN Red List Status:** Critically Endangered
    - ✓ **CITES:** Appendix II

Spider – CR – Rameshwaram Parachute Spider

- Rameshwaram Ornamental was recently described in 2004 and is **only found in India**.
- The species is semi-social, which means they live partly in groups.
- **Habitat:** Arboreal (living in trees) and tend to live in hiding.
- **Distribution:** Endemic to India. Spread along the coastal savannah, tropical lowland rain forests and montane forests up to an altitude of 2000 m above mean sea level.

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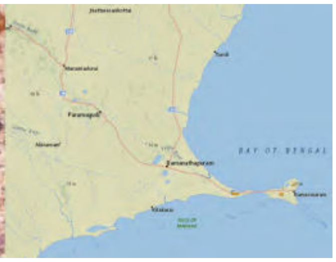
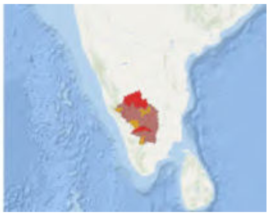


- **Threats:** Major threats causing the disappearance of this species is habitat alteration and degradation.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA:**
  - ✓ **CITES:** Appendix II

36.7.18. Fish – Critically Endangered (CR)

Fish – CR – Hump Backed Mahseer

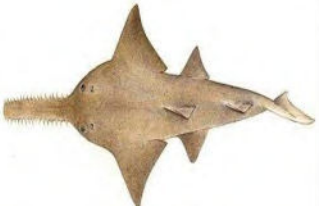
- The humpbacked mahseer is a large **freshwater fish.**
- Fish **endemic to the Western Ghats of India**.
- It is found **only in the Cauvery River basin**.
- It is also known as the **Tiger of the Water**.



- **Threats:** dams, destructive fishing methods, reduced water flow rates, water & pollution, etc.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered

Fish – CR – Largetooth Sawfish

- **Distribution:** Western part of the Indo-Pacific.
- In India, it is known to enter the **Mahanadi River**, up to 64 km inland, and also is very common in the estuaries of the Ganga and Brahmaputra.



- **Threats:** Fisheries, Internationally traded for its meat & fins, Habitat changes include construction of dams over rivers, siltation, pollution from industries and mining operations.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Fish – CR – Long-comb Sawfish/Narrow-snout Sawfish (Pristis zijsron)

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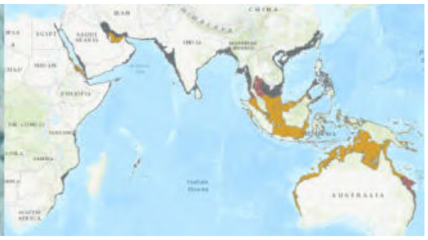
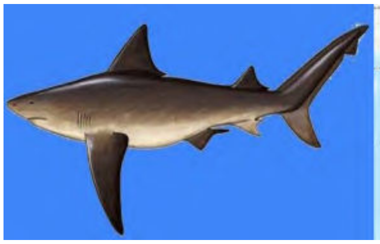
- Green Sawfish species is native to **tropical & sub-tropical waters.**
- **Habitat:** It inhabits muddy bottoms and also enters estuaries.
- **Distribution: Indo-Pacific region** including Australia, Cambodia, China, India, Indonesia and Malaysia.



- **Threats:** Traded for its highly valuable fins , Used in Asian traditional medicine, fishing is the main threat.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

Fish – CR – The Ganges Shark

- Ganges Shark occurs in the **turbid waters** of the **Ganga River (Padma River), Brahmaputra River & Bay of Bengal**.
- The small eyes suggest that it is adapted to living in turbid water **(just like dugong)**, while the slender teeth of the species suggest that it is primarily a fish-eater.
- **Distribution:** The Ganga River system and Hooghly River mouth are its known habitats.



- **Threats:** Major fisheries targeting sharks. Other probable threats include overfishing, pollution, increasing river use and construction of dams and barrages.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **WPA: Schedule I**

Fish – CR – The Pondicherry Shark

- Pondicherry shark appears to have been broadly distributed in the **Indo-Pacific**.
- **Distribution:** Indian Ocean – from **Gulf of Oman to Pakistan, India & Sri Lanka**.
- In scattered localities spanning India to New Guinea. Also been recorded at the mouth of the **Hooghly River.**

- **Threats:** Large, expanding, and unregulated commercial fisheries in inshore localities and habitats.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered

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- ✓ **WPA: Schedule I**

Fish – CR – White spotted wedgefish/ Bottlenose wedgefish

- Bottlenose Wedge fish is found in the **Indo-Pacific Region.**
- **Distribution:** Red Sea, Persian Gulf, and the western Indian Ocean.

- **Threats:** High levels of exploitation for its flesh and fins.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Critically Endangered
  - ✓ **CITES:** Appendix II

36.7.19. Fish – Endangered (EN)

Fish – EN – Knifetooth Sawfish/Narrow Sawfish (Anoxypristis cuspidata)

- **Distribution:** Widespread in the **western part of the Indo-Pacific region**, including the Red Sea.

- **Threats:** Similar to Long-comb Sawfish.
- **Conservation Status:**
  - ✓ **IUCN Red List Status:** Endangered
  - ✓ **WPA: Schedule I**
  - ✓ **CITES:** Appendix I

36.7.20. Fish – Least Concern (LC)

Fish – LC – Blue-finned Mahseer

- It IUCN status was upgraded from Endangered to the **Least Concern**.
- Habitat: **most waters of the Peninsular Plateau**.

Q. Consider the following pairs: (2019)

Wildlife: Naturally found in

1) Blue finned mahseer: Cauvery river
2) Irrawaddy dolphin: Chambal river
3) Rusty spotted cats: Eastern ghats

Which one of the pair given above are correctly matched?

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a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Explanation:

- The range of Irrawaddy Dolphin in India is confined to the east coast from West Bengal to Chilika Lake.

Answer: c) 1 & 3 only

36.7.21. Insects

Insects – LC – Golden Birdwing (Troides aeacus)

- Golden Birdwing is **India's largest butterfly with a wingspan** of 194 mm.
- It has **replaced Southern Birdwing** as the largest butterfly in India.
- **Distribution:** It is found in northern India, Nepal, Burma, China, Thailand, Laos, Vietnam, Taiwan, Cambodia, peninsular Malaysia and Indonesia.

- **Conservation Status:**
  - ✓ **IUCN Red List status:** Least Concern
  - ✓ **CITES:** Appendix II

36.7.22. Plants

Plants – CR – Eulophia Obtusa

- In India, the species is listed as **"Critically Endangered" in the IUCN Red List of endangered species** — it was last recorded in **Pilibhit in 1902.**
- In 2008, the plant species was sighted in Bangladesh for the first time.
- Also known as **'Ground Orchid'**, it has been rediscovered in India in **Dudhwa Tiger Reserve**.

Plants – EN – Globba Andersonii

- Globba Andersonii is commonly known as **'Dancing Ladies' or 'Swan Flowers'** plant.
- **Habitat & Distribution:** Restricted to the **Teesta River Valley** (Sikkim Himalayas & Darjeeling hills).
- The plant grows in a dense colony as a **lithophyte** (plant growing on bare rock) near evergreen forests.

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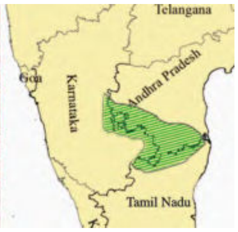
- **Conservation Status:**
    - ✓ **IUCN Red List Status:** Endangered

Plants – EN – Red Sanders

- Red Sanders is a small tree that grows to 5-8 meters in height and has dark greyish bark.
- **Habitat: Tropical Dry Deciduous Forest.**
- **Distribution:** A native and **endemic to India** & can only be found in the **southern parts of the Eastern Ghats**, **Palakonda & Seshachalam hill ranges** of **Andhra Pradesh** & also found in **Kerala, Tamil Nadu & Karnataka**.
- **Uses:**
    - ✓ High demand in East Asian countries.
    - ✓ Red Sandalwood timber is **used for** carvings, furniture, poles, and house posts.
    - ✓ In addition, the timber is also exploited for the extraction of **Santalin (Red pigment used as dye and colourant in food)**, medicine and cosmetics.
- Threats: illegal logging and smuggling, sandalwood spike disease.



- **Conservation Status:**
    - ✓ **IUCN Red List status:** Endangered
    - ✓ **CITES Listed:** Appendix II

Plants – VU – Indian Rosewood

- Indian Rosewood is commonly known as **Sheesham.**
- It can grow in slightly **saline soil.**
- It is the **state tree of Punjab.**

- It is best known internationally as a premier timber species of the rosewood genus. However, Shisham is also important fuelwood, shade, and shelter.

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- **Habitat:** Native to the foothills of the Himalayas
- **Distribution:** Foothills of the Himalayas ranging from Afghanistan in the west to Bihar, India, in the east. It also occurs naturally in Iran.
- **Threats:** Logging & wood harvesting**.**
- **Conservation Status:**
  - **IUCN Red List Status:** Vulnerable
  - **CITES:** Appendix II
- **Note:** India has **proposed to remove rosewood** from **Appendix II of CITES**, a multilateral treaty to protect endangered plants and animals.

36.7.23. Others

Reptiles – DD – Assam Keelback Snake

- More than a century after it was first seen, the Assam keelback was rediscovered in 2018.
- It is a **non–venomous** snake **endemic to the region**
- **Conservation Status**:
  - ✓ **IUCN Red List Status**: **'Data Deficient'**

Amphibians – Kalinga Cricket Frog

- Kalinga Cricket Frog is thought to be **endemic to the hill ranges of the Eastern Ghats.**
- It is found on the **higher-elevation hill ranges of Odisha and Andhra Pradesh**.
- Cricket frogs are indicators of a healthy ecosystem and live in wide habitat ranges in agricultural fields, streams, swamps and wetlands.

Adaptive Mechanisms

- **Morphological Phenotypic Plasticity:** cricket frogs are able to show drastic morphological (physical features) variations in response to natural environmental variations or stimuli.
- Frogs are known to exhibit varied reproductive behaviours by adopting different modes and strategies for successful survival.

Plants – Blue Poppy

- **Blue poppy is considered the Queen of Himalayan Flowers.**
- It is the **National Flower of Bhutan**.
- It is **native to the Himalayas**, northern Burma, Tibet & Yunnan Province in China.
- In India, it is found from Kumaon to Kashmir at elevations of 3,000 to 5,000 meters.
- Threats: Fragile per–glacial ecosystems have seen a depletion in Blue Poppy species.

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37. Protected Area Network

- India has a network of ~880 Protected Areas covering a total of ~1,66,500 km^2 **(~5.06%)** of geographical area.

Protected Areas of India (July 2021)			
Protected Area Type	**Number**	**Total Area (Km^2)**	**Coverage % of Country**
National Parks (NPs)	**106**	**41,157**	**1.23**
Wildlife Sanctuaries (WLSs)	**568**	**~120,500**	**3.64**
Conservation Reserves (CRs)	88	4,356	0.13
Community Reserves	127	525	0.02
Protected Areas (PAs)	**~889**	**~1,66,500 Km^2**	**~5.06**

- **BR: Biosphere Reserve (A BR may consist of a few NPs, wildlife sanctuaries, protected and reserve forests)**
- **NP: National Park**
- **TR: Tiger Reserve (A TR may consist of an NP, a few wildlife sanctuaries and protected and reserve forests)**
- **WLS: Wildlife Sanctuary**
- **BS: Bird Sanctuary** (a Bird Sanctuary is a WLS that conserves birds and their natural habitats)
- **PF: Protected Forest**
- **RF: Reserve Forest**
- **ER: Elephant Reserve**
- **RS: Ramsar Site**

In terms of protection, National Parks > Wildlife Sanctuary > Reserved forests > Protected forests

37.1. National Parks of India

S.No.	State (number of NPs)	Name of State/ Protected Area	Year	Area (km^2)
1	**Andaman & Nicobar Islands (9)**	1. Campbell Bay NP	1992	426.23
2		2. Galathea Bay NP	1992	110
3		3. Mahatama Gandhi Marine (Wandoor) NP	1983	281.5
4		4. Middle Button Island NP	1987	0.44
5		5. Mount Harriett NP	1987	46.62
6		6. North Button Island NP	1987	0.44
7		7. Rani Jhansi Marine NP	1996	256.14
8		8. Saddle Peak NP	1987	32.54
9		9. South Button Island NP	1987	0.03
10	Andhra Pradesh (3)	1. Papikonda NP	2008	1013
11		2. Rajiv Gandhi (Rameswaram) NP	2005	2.4
12		3. Sri Venkateswara NP	1989	353.6
13	Arunachal Pradesh (2)	1. Mouling NP	1986	483
14		2. Namdapha NP	1983	1808
15	**Assam (7)**	1. Dibru-Saikhowa NP	1999	340
16		2. Kaziranga NP	1974	859

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17		3. Manas NP	1990	500
18		4. Nameri NP	1998	200
19		5. Rajiv Gandhi Orang NP	1999	78.81
20		**6. Raimona NP**	2021	422
21		**7. Dihing Patkai NP**	2021	234
22	**Bihar (1)**	1. Valmiki NP	1989	335.65
23	Chhattisgarh (3)	1. Guru Ghasidas (Sanjay) NP	1981	1440.7
24		2. Indravati (Kutru) NP	1982	1258.4
25		3. Kanger Valley NP	1982	200
26	Goa (1)	1. Mollem NP	1992	107
27	Gujarat (4)	1. Vansda NP	1979	23.99
28		2. Blackbuck (Velavadar) NP	1976	34.53
29		3. Gir NP	1975	258.71
30		4. Marine (Gulf of Kachchh) NP	1982	162.89
31	Haryana (2)	1. Kalesar NP	2003	46.82
32		2. Sultanpur NP	1989	1.43
33	Himachal Pradesh (5)	1. Great Himalayan NP	1984	754.4
34		2. Inderkilla NP	2010	104
35		3. Khirganga NP	2010	710
36		4. Pin Valley NP	1987	675
37		5. Simbalbara NP	2010	27.88
38	UT of Jammu & Kashmir (3)	1. City Forest (Salim Ali) NP (J&K)	1992	9
39	UT of Ladakh (1)	2. Dachigam NP (J&K)	1981	141
40		3. Hemis NP (Ladakh)	1981	3350
41		4. Kishtwar NP (J&K)	1981	425
42	Jharkhand (1)	1. Betla NP	1986	226.33
43	Karnataka (5)	1. Anshi NP	1987	417.34
44		2. Bandipur NP	1974	874.2
45		3. Bannerghatta NP	1974	260.51
46		4. Kudremukh NP	1987	600.32
47		5. Nagarahole (Rajiv Gandhi) NP	1988	643.39
48	Kerala (6)	1. Anamudi Shola NP	2003	7.5
49		2. Eravikulam NP	1978	97
50		3. Mathikettan Shola NP	2003	12.82
51		4. Pambadum Shola NP	2003	1.318
52		5. Periyar NP	1982	350
53		6. Silent Valley NP	1984	89.52
54	**Madhya Pradesh (10)**	1. Bandhavgarh NP	1968	448.85

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55		2. Dinosaur Fossils NP	2011	0.8974
56		3. Fossil NP	1983	0.27
57		4. Indira Priyadarshini Pench NP	1975	292.85
58		5. Kanha NP	1955	940
59		6. Madhav NP	1959	375.22
60		7. Panna NP	1981	542.67
61		8. Sanjay NP	1981	466.88
62		9. Satpura NP	1981	585.17
63		10. Van Vihar NP	1979	4.45
64	Maharashtra (6)	1. Chandoli NP	2004	317.67
65		2. Gugamal NP	1975	361.28
66		3. Nawegaon NP	1975	133.88
67		4. Pench (Jawaharlal Nehru) NP	1975	257.26
68		5. Sanjay Gandhi (Borivilli) NP	1983	86.96
69		6. Tadoba NP	1955	116.55
70	Manipur (1)	1. Keibul-Lamjao NP (in Loktak Lake)	1977	40
71	Meghalaya (2)	1. Balphakram NP	1985	220
72		2. Nokrek Ridge NP	1986	47.48
73	Mizoram (2)	1. Murlen NP	1991	100
74		2. Phawngpui Blue Mountain NP	1992	50
75	Nagaland (1)	1. Intanki NP	1993	202.02
76	Odisha (2)	1. Bhitarkanika NP	1988	145
77		2. Simlipal NP	1980	845.7
78	Rajasthan (5)	1. Desert NP	1992	3162
79		2. Keoladeo Ghana NP	1981	28.73
80		3. Mukundra Hills NP	2006	200.54
81		4. Ranthambhore NP	1980	282
82		5. Sariska NP	1992	273.8
83	Sikkim (1)	1. Khangchendzonga NP	1977	1784
84	Tamil Nadu (5)	1. Guindy NP	1976	2.82
85		2. Gulf of Mannar Marine NP	1980	6.23
86		3. Indira Gandhi (Annamalai) NP	1989	117.1
87		4. Mudumalai NP	1990	103.23
88		5. Mukurthi NP	1990	78.46
89	Telangana (3)	1. Kasu Brahmananda Reddy NP	1994	1.43
90		2. Mahaveer Harina Vanasthali NP	1994	14.59
91		3. Mrugavani NP	1994	3.6
92	Tripura (2)	1. Clouded Leopard NP	2007	5.08

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93		2. Bison (Rajbari) NP	2007	31.63
94	Uttar Pradesh (1)	1. Dudhwa NP	1977	490
95	Uttarakhand (6)	1. Corbett NP	1936	520.82
96		2. Gangotri NP	1989	2390.02
97		3. Govind NP	1990	472.08
98		4. Nanda Devi NP	1982	624.6
99		5. Rajaji NP	1983	820
100		6. Valley of Flowers NP	1982	87.5
101	West Bengal (6)	1. Buxa NP	1992	117.1
102		2. Gorumara NP	1992	79.45
103		3. Jaldapara NP	2014	216.51
104		4. Neora Valley NP	1986	159.89
105		5. Singalila NP	1986	78.6
106		6. Sunderban NP	1984	1330.1
				~41,157

30 Largest National Parks in terms of area				**Descending order of States in terms of number of National Parks**		
Rank	**National Park**	**Area (km²)**		**Rank**	**State**	**No. of NPs**
1	**Hemis NP**	**3,350**		**1**	**Madhya Pradesh**	**10**
2	**Desert NP**	**3,162**		**2**	**Andaman & Nicobar**	**9**
3	**Gangotri NP**	**2,390**		**3**	**Assam**	**7**
4	**Namdapha NP**	**1,808**		**4**	**Kerala**	**6**
5	**Khangchendzonga NP**	**1,784**		**5**	**Maharashtra**	**6**
6	**Guru Ghasidas (Sanjay) NP**	**1,441**		**6**	**Uttarakhand**	**6**
7	**Sunderban NP**	**1,330**		7	**West Bengal**	**6**
8	**Indravati (Kutru) NP**	**1,258**		8	Himachal Pradesh	5
9	**Papikonda NP**	**1,013**		9	Karnataka	5
10	**Kanha NP**	**940**		10	Rajasthan	5
11	Bandipur NP	874		11	Tamil Nadu	5
12	Kaziranga NP	859		12	Gujarat	4
13	Simlipal NP	846		13	J&K UT + Ladakh UT	4
14	Rajaji NP	820		14	Andhra Pradesh	3
15	Great Himalayan NP	754		15	Chhattisgarh	3
16	Khirganga NP	710		16	Telangana	3
17	Pin Valley NP	675		17	Arunachal Pradesh	2
18	Nagarahole (Rajiv Gandhi) NP	643		18	Haryana	2
19	Nanda Devi NP	625		19	Meghalaya	2
20	Kudremukh NP	600		20	Mizoram	2
21	Satpura NP	585		21	Odisha	2
22	Panna NP	543		22	Tripura	2

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23	Corbett NP	521
24	Manas NP	500
25	Dudhwa NP	490
26	Mouling NP	483
27	Govind NP	472
28	Sanjay NP	467
29	Bandhavgarh NP	449
30	Campbell Bay NP	426

Smallest National Parks in terms of Area		
Rank	**National Park**	**Area (km²)**
1	**South Button Island NP**	**0.03**
2	**Fossil NP**	**0.3**
4	North Button Island NP	0.4
5	Middle Button Island NP	0.9
6	North Button Island NP	1.3
7	Dinosaur Fossils NP	1.4
8	Pambadum Shola NP	1.4

23	Bihar	1
24	Goa	1
25	Jharkhand	1
26	Manipur	1
27	Nagaland	1
28	Sikkim	1
29	Uttar Pradesh	1

Oldest National Parks		
	NP	**Year**
1	**Corbett NP**	**1936**
2	**Kanha NP**	**1955**
3	**Tadoba NP**	**1955**

Newest National Parks		
	NP	**Year**
1	**Dihing Patkai NP**	2021
2	**Raimona NP**	2021
3	**Jaldapara NP**	2014

37.2. Tiger Reserves of India

	State/UT	Tiger Reserve	Core area (In Sq. Kms.)	Buffer area (In Sq. Kms.)	Total Area (In Sq. Kms.)
1	Andhra Pradesh	Nagarjunsagar Srisailam (1982-83)	2595.72	700.59	3296.31
2	Arunachal Pradesh	Namdapha (1982-83)	1807.82	245	2052.82
3		Pakke (1999-2000)	683.45	515	1198.45
4		Kamlang (2016)	671	112	783
5	Assam	Manas (1973-74)	526.22	2310.88	2837.1
6		Nameri (1999-2000)	320	144	464
7		Kaziranga (2008-09)	625.58	548	1173.58
8		Orang (2016)	79.28	413.18	492.46
9	Bihar	Valmiki (1989-90)	598.45	300.93	899.38
10	Chhattisgarh	Udanti-Sitanadi (2008-09)	851.09	991.45	1842.54
11		Achanakmar (2008-09)	626.195	287.822	914.017
12		Indravati (1982-83)	1258.37	1540.7	2799.07
13	Jharkhand	Palamau (1973-74)	414.08	715.85	1129.93
14	Karnataka	Bandipur (1973-74)	872.24	584.06	1456.3
15		Bhadra (1998-99)	492.46	571.83	1064.29
16		Dandeli-Anshi (Kali) (2008-09)	814.884	282.63	1097.514
17		Nagarahole (2008-09)	643.35	562.41	1205.76
18		Biligiri Ranganatha Temple (2011)	359.1	215.72	574.82
19	Kerala	Periyar (1978-79)	881	44	925
20		Parambikulam (2008-09)	390.89	252.772	643.662
21	Madhya Pradesh	Kanha (1973-74)	917.43	1134.361	2051.791

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22		Pench (1992-93)	411.33	768.3023	1179.632
23		Bandhavgarh (1993-94)	716.903	820.0351	1598.1
24		Panna (1994-95)	576.13	1021.97	1598.1
25		Satpura (1999-2000)	1339.264	794.044	2133.308
26		Sanjay-Dubri (2008-09)	812.571	861.931	1674.502
27	Maharashtra	Melghat (1973-74)	1500.49	1268.03	2768.52
28		Tadoba-Andhari (1993-94)	625.82	1101.771	1727.591
29		Pench (1998-99)	257.26	483.96	741.22
30		Sahyadri (2009-10)	600.12	565.45	1165.57
31		Nawegaon-Nagzira (2013-14)	653.674	1241.27	1894.944
32		Bor (2014)	138.12	678.15	816.27
33	Mizoram	Dampa (1994-95)	500	488	988
34	Odisha	Similipal (1973-74)	1194.75	1555.25	2750
35		Satkosia (2008-09)	523.61	440.26	963.87
36	Rajasthan	Ranthambore (1973-74)	1113.364	297.9265	1411.291
37		Sariska (1978-79)	881.1124	332.23	1213.342
38		Mukandra Hills (2013-14)	417.17	342.82	759.99
39		**Ramgarh Vishdhari (June 2021)**	309	740	1052
40	Tamil Nadu	Kalakad-Mundanthurai (1988-89)	895	706.542	1601.542
41		Mudumalai (2008-09)	321	367.59	688.59
42		Sathyamangalam (2013-14)	793.49	614.91	1408.4
43		Anamalai (2008-09)	958.59	521.28	1479.87
44		**Srivilliputhur-Megamalai (Feb 2021)**	**641**	374	**1016**
45	Telangana	Kawal (2012-13)	892.23	1123.212	2015.44
46		Amrabad (2014)	2166.37	445.02	2611.39
47	Uttar Pradesh	Dudhwa (1987-88)	1093.79	1107.985	2201.775
48		Pilibhit (2014)	602.798	127.4518	730.2498
49	Uttarakhand	Corbett (1973-74)	821.99	466.32	1288.31
50		Rajaji (2015)	819.54	255.63	1075.17
51	West Bengal	Sunderbans (1973-74)	1699.62	885.27	2584.89
52		Buxa (1982-83)	390.5813	367.3225	757.9038
		Total	**40145.3**	**32603.72**	**72749.02**

Largest Tiger Reserves				**Descending order of States in terms of number of Tiger Reserves**		
Rank	**Name of Tiger Reserve**	**Core Area in km²**		**Rank**	**State**	**No. of TRs**
1	**Nagarjunasagar Srisailam**	**2,596**		**1**	**Maharashtra**	**6**
2	**Amrabad**	**2,166**		**2**	**Madhya Pradesh**	**6**
3	**Namdapha**	**1,808**		**3**	**Karnataka**	**5**
4	Sunderbans	1,700		4	Rajasthan	4
5	Melghat	1,500		5	Tamil Nadu	4
6	Satpura	1,339		6	Assam	4
7	Indravati	1,258		7	Arunachal Pradesh	3
8	Similipal	1,195		8	Telangana	2

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9	Ranthambore	1,113		9	West Bengal	2
10	Dudhwa	1,094		10	Odisha	2
Smallest Tiger Reserves in terms of Area				11	Uttar Pradesh	2
Rank	**Name of Tiger Reserve**	**Core Area in km²**		12	Kerala	2
1	**Orang Tiger Reserve**	79		13	Chhattisgarh	2
2	Bor	138		14	Uttarakhand	2
3	Nameri	200		15	Andhra Pradesh	1
4	Rajaji TR	256		16	Chhattisgarh	1
5	Pench	257		17	Bihar	1
6	Mudumalai	321		18	Mizoram	1
7	Biligiri Ranganatha Temple	359		19	Jharkhand	1
8	Buxa	391		20	Assam	1
9	Parambikulam	391				

Q. Among the following Tiger Reserves, which one has the largest area under "Critical Tiger Habitat"?

a) Corbett
b) Ranthambore
c) Nagarjunsagar-Srisailam
d) Sunderbans

Answer: Nagarjunsagar-Srisailam > Sundarbans > Ranthambore; c) Nagarjunsagar-Srisailam

37.3. Description of National Parks and Tiger Reserves

37.3.1. Andaman & Nicobar Islands

Campbell Bay & Galathea National Parks (Great Nicobar)

- They are a part of the **Great Nicobar Biosphere Reserve**. Both the parks are separated by a 12-km wide forest buffer zone.
- **Galathea National Park** is the **southernmost National Park of India**.
- Vegetation: tropical moist broadleaf forests: evergreen & semi-evergreen deciduous tree species.
- Major Fauna: giant robber crab, megapode and **Nicobar pigeon**.

Mahatama Gandhi Marine National Park (South Andaman)

- **Mahatama Gandhi Marine (Wandoor) National Park** is located in the **South Andaman** district.
- It was declared a national park to protect **corals** and nesting **sea turtles** prevalent in the area.
- Most of the coral reefs in the park are **fringing reefs**.
- **Mangroves** are the major vegetation.

Mount Harriett National Park (Near Port Blair; South Andaman)

- Mount Harriet (383 metres) is the third-highest peak in the Andaman and Nicobar archipelago.
- The park is named after Harriet C. Tytler, wife of a British army officer.
- Harriet is remembered for her work in documenting the monuments of Delhi.
- Major Fauna: Andaman wild pigs, **saltwater crocodiles**, turtles and robber crabs.
- The park is also a **butterfly hotspot**.

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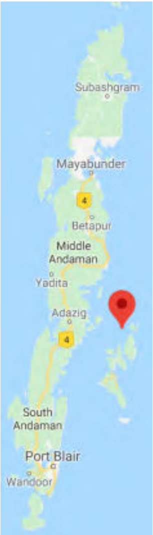
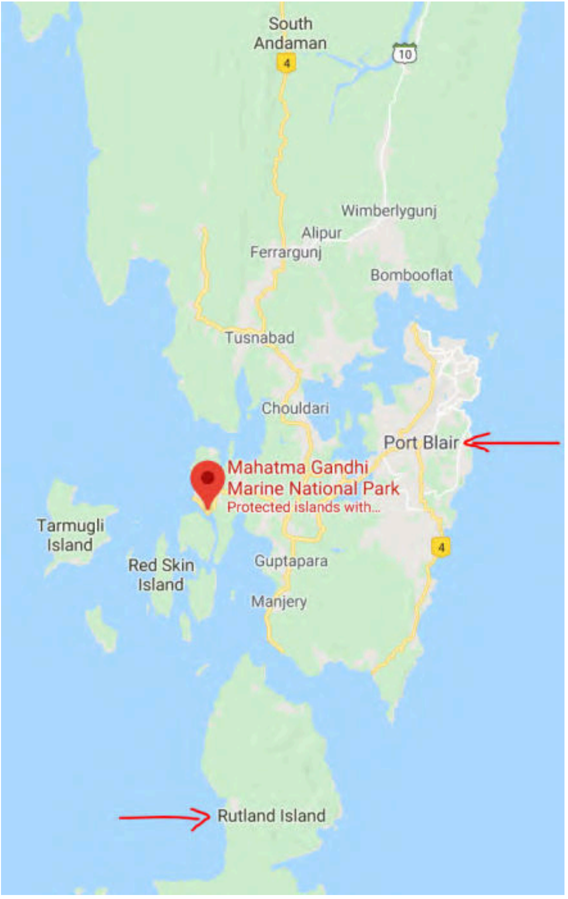
Rani Jhansi Marine National Park

- **North Button, Middle Button** and **South Button Islands** (also national parks) form a part of the Rani Jhansi Marine National Park off the coast of **South Andaman Island**.
- Major terrestrial Fauna: spotted deer, water lizards and monitor lizards.
- Major marine Fauna: **dugongs**, dolphins, sea turtles, blue whales, corals, etc.
- South Button Island is too small to support any major terrestrial life.





Saddle Peak National Park

- **Saddle peak** is the **highest point (732 metres) of Andaman and Nicobar Islands**.
- Major Fauna: Andaman wild pig, Andaman imperial pigeon, dolphins, whales and **saltwater crocodile**.

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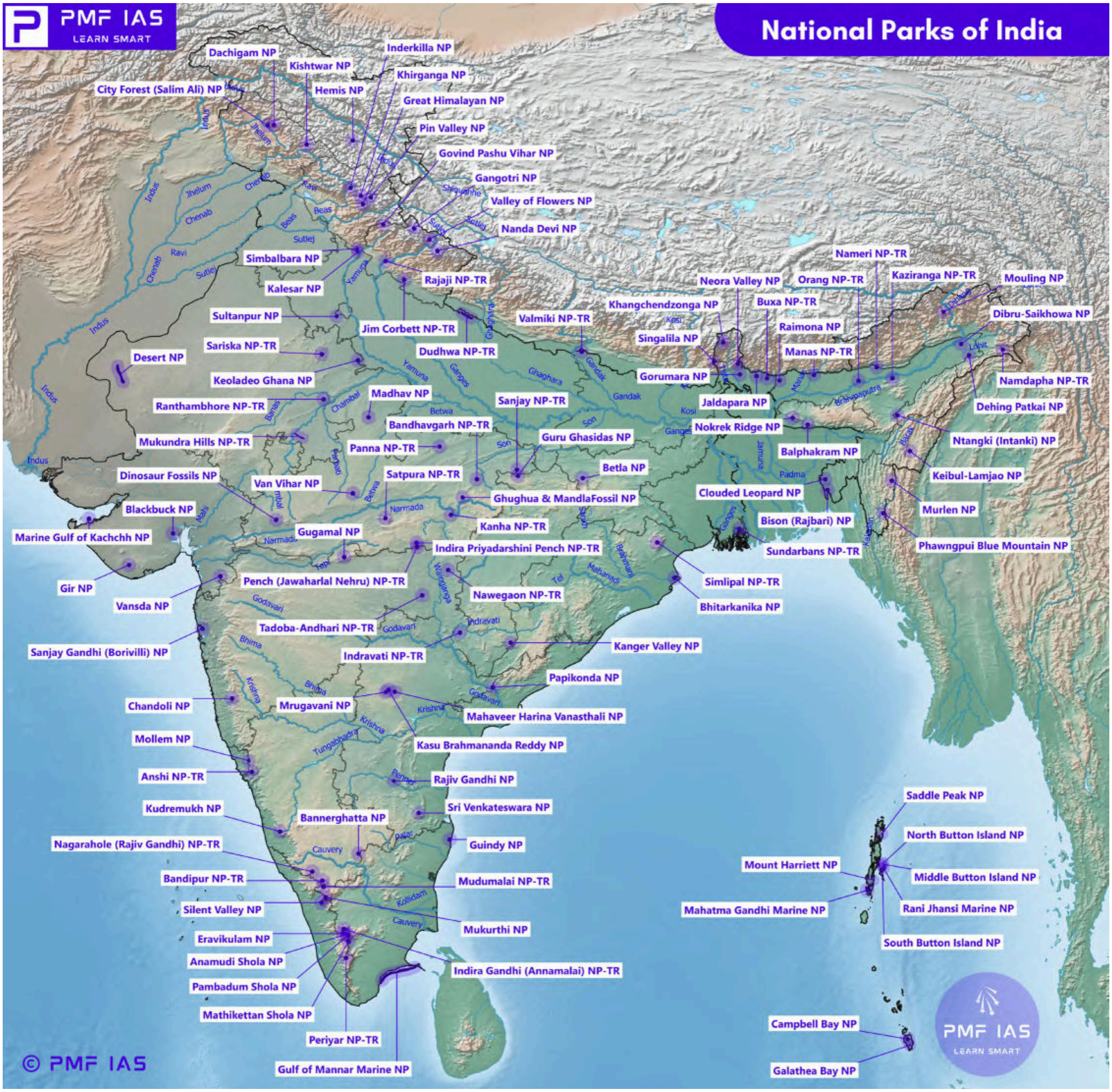

37.3.2. Andhra Pradesh

Nagarjunasagar Srisailam Tiger Reserve

- It is the **largest tiger reserve in India**.
- It forms a major part of the **Nallamala Hills**.
- It spreads over **AP** (Kurnool, Prakasam, Guntur districts) and **Telangana** (Nalgonda, Mahbubnagar districts).
- The **Krishna River** cuts through the reserve.
- The **Srisailam reservoir** (on **River Krishna**) and temple lie in the reserve.
- The **Nagarjunasagar Dam and reservoir** lie near the northern boundary of the reserve.
- Vegetation: tropical dry mixed deciduous forest.

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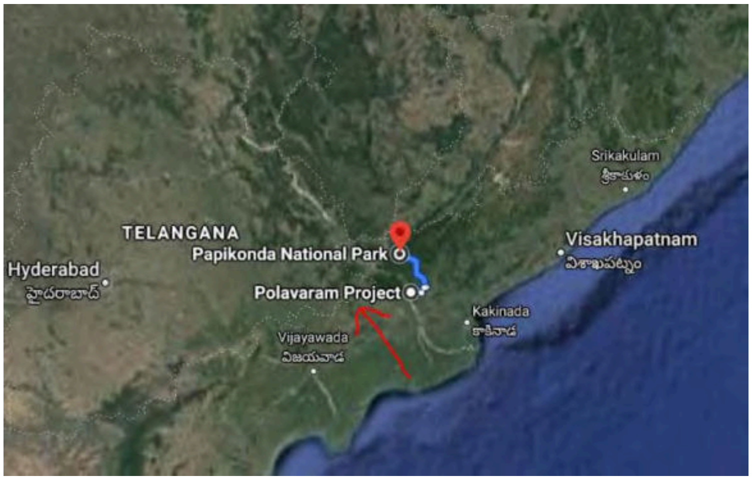
- Major Fauna: Bengal tiger, Indian leopard, Indian pangolin, chital, sambar deer, blackbuck, chinkara, chausingha, **mugger crocodile (marsh crocodile)**, etc.

Papikonda National Park

- Located in the **Eastern Ghats** in East & West Godavari districts of Andhra Pradesh.
- It is an Important **Bird and Biodiversity Area**.



- Major Fauna: Indian leopard, rusty-spotted cat, sloth bear, small Indian civet, Asian palm civet, wild boar, spotted deer, sambar deer, gaur, nilgai, four-horned antelope, etc.
- The National Park has a population of **both Rhesus macaque which are normally found north of Godavari** and **Bonnet macaque that are usually found south of Godavari**.
- The **Polavaram irrigation project,** once completed, will submerge parts of the National Park.

Rajiv Gandhi (Rameswaram) National Park

- The park is located close to the upper bank of the **river Penna** in the Cuddapah district.
- It is semi-arid and mostly sandy.
- Vegetation: Tropical dry deciduous forest.
- Major Fauna: Spotted deer, Common mongoose, etc. reside in this sand dune ecosystem.

Sri Venkateswara National Park, Wildlife Sanctuary

- The NP is a part of the **Seshachalam Hills Biosphere Reserve**.
- It is located in the **Eastern Ghats** spread over the **Seshachalam hills (Tirumala hills)** of Kadapa and Chittoor.
- The **Penna River** divides the **Nallamala Hills (north) from the Seshachalam hills (south)**.
- **The famous Lord Venkateshwara Temple, Tirumala (Tirupati),** is located in the hills.
- Vegetation: mix of dry deciduous and moist deciduous types.
- Major Flora: rare and endemic plant species like **red sanders** are of great economic importance.
- Avian Fauna: The globally threatened yellow-throated bulbul, grey-fronted green pigeon, etc.
- Major Fauna: leopard, wild dog (dhole), golden jackal, small Indian civet, sloth bear, sambar, spotted deer, mouse deer, barking deer, four-horned antelope, wild boar, Indian giant squirrel, etc.
- Major Reptilian Fauna: gliding lizard, **golden gecko**, etc.
- Threats: construction of infrastructure for Tirupati pilgrims and quarrying.

37.3.3. Arunachal Pradesh

Kamlang Tiger Reserve, Wildlife Sanctuary

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- It is named after the **Kamlang River,** which flows through it.
- It lies in between the **Lohit River** and **Namdapha National Park**.
- Wildlife in the Park is similar to that found in the contiguous area of the **Namdapha Tiger Reserve**.
- Major Fauna: elephant, tiger, leopard, stump-tailed macaque, capped langur, hornbills, flying squirrel etc.

Mouling National Park

- A part of **The Mouling NP** and the **Dibang WLS** are located within **Dihang-Dibang Biosphere Reserve**.
- The terrain is rugged, with an altitudinal range of 750 to 3000 m at the highest point, the **Mouling Peak**.
- The **Siyom river** flows along the western fringes of the park and flows into the **Siang River (Brahmaputra River is known as Siang in Arunachal Pradesh)** near the eastern boundary of the park.
- Climate: extremely humid, with heavy rainfall and no well-defined dry season.
- Vegetation: tropical forests at lower altitudes to most temperate forest at altitudes above 2800 m.
- Major Fauna: **takin**, Indian leopard, Bengal tiger, barking deer, serow, **red panda**, etc.

Namdapha Tiger Reserve, National Park

- It is located between the **Dapha bum range** of the **Mishmi Hills** and the **Patkai range** with a wide elevation range between 200 and 4,571 m.
- It is crossed from east to west by the **Noa Dihing River** that originates at the **Chaukan Pass**.
- Vegetation: vegetation zones from evergreen, moist deciduous to temperate broadleaved and coniferous forest types to alpine vegetation. Additionally, the park has **extensive bamboo forests**.

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Major Fauna

- **Namdapha flying squirrel (CR)** is endemic to the park.
- Four pantherine species: **leopard** (Panthera pardus), **snow leopard**, **tiger** and **clouded leopard**.
- Other predators: dhole, Malayan sun bear, Indian wolf and **Asiatic black bear**.
- Smaller carnivores: **red panda**, red fox, Asian golden cat, etc.
- Large herbivores: **Indian elephant**, wild boar, **musk deer**, **hog deer, sambar**, gaur, takin, **bharal (blue sheep)**.
- Non-human primates: stump-tailed macaque, Assamese macaque and **rhesus macaque**.

Pakke (Pakhui) Tiger Reserve

- It lies in the **foothills of the Himalayas** in Pakke Kessang District at an altitude ranging from 150 to 2,000 m.
- The reserve is known for its **Hornbill Nest Adoption Programme**.

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- It is bounded by **Kameng River** in the west and north, and by **Pakke River** in the east.
- Towards the south and south-east, the sanctuary adjoins **Assam's Nameri National Park**.
- To the west, it is bounded by and **Eaglenest Wildlife Sanctuary** and **Sessa Orchid Sanctuary**.
- Vegetation: lowland semi-evergreen, evergreen forest and Himalayan broadleaf forests.
- Major Fauna: Bengal tiger, Indian leopard, clouded leopard, elephant, barking deer, gaur, sambar, rhesus macaque, Assamese macaque, etc.

37.3.4. Assam

Dihing Patkai National Park, Elephant Reserve

- It is located in the Dibrugarh and Tinsukia districts of Upper Assam — rich in coal and oil.
- It includes areas falling within the existing **Dehing Patkai Wildlife Sanctuary** along with **Upper Dehing reserve forest** (West Block) and **Jeypore reserve forest**.

- It is the 7th **national Park of Assam** and the **newest in India** (as of August 2021).
- Vegetation: **Assam Valley Tropical Wet Evergreen Forest (Assam-Arunachal interstate boundary)**.

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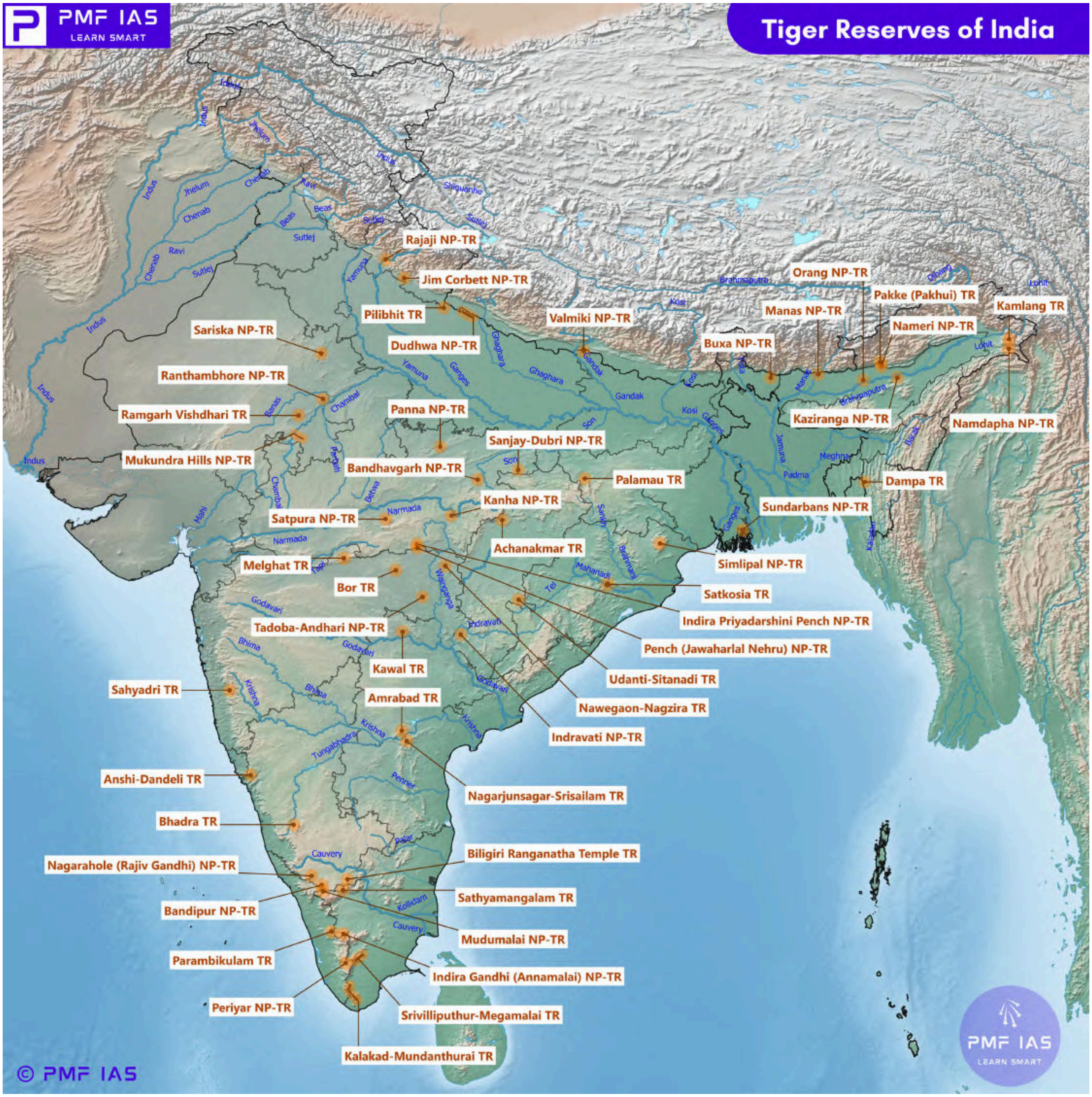
- Major Fauna: **hoolock gibbon**, elephant, slow loris, tiger, leopard, **clouded leopard**, **golden cat**, fishing cat, **marble cat, sambar, hog deer**, sloth bear, and Assam's state bird, the **white-winged wood duck (EN)**.
- Threats: **coal mining, oil extraction**, tea gardens, village settlements, deforestation, etc.
- The **oldest refinery of Asia in Digboi** and **'open cast' coal mining at Lido** are located near the park.



Dibru-Saikhowa National Park

- It is a designated **Biosphere Reserve**.
- The park is bounded by the **Brahmaputra** and **Lohit Rivers** in the north and **Dibru river** in the south.
- Vegetation: moist semi-evergreen forests, moist mixed deciduous forests and grasslands.

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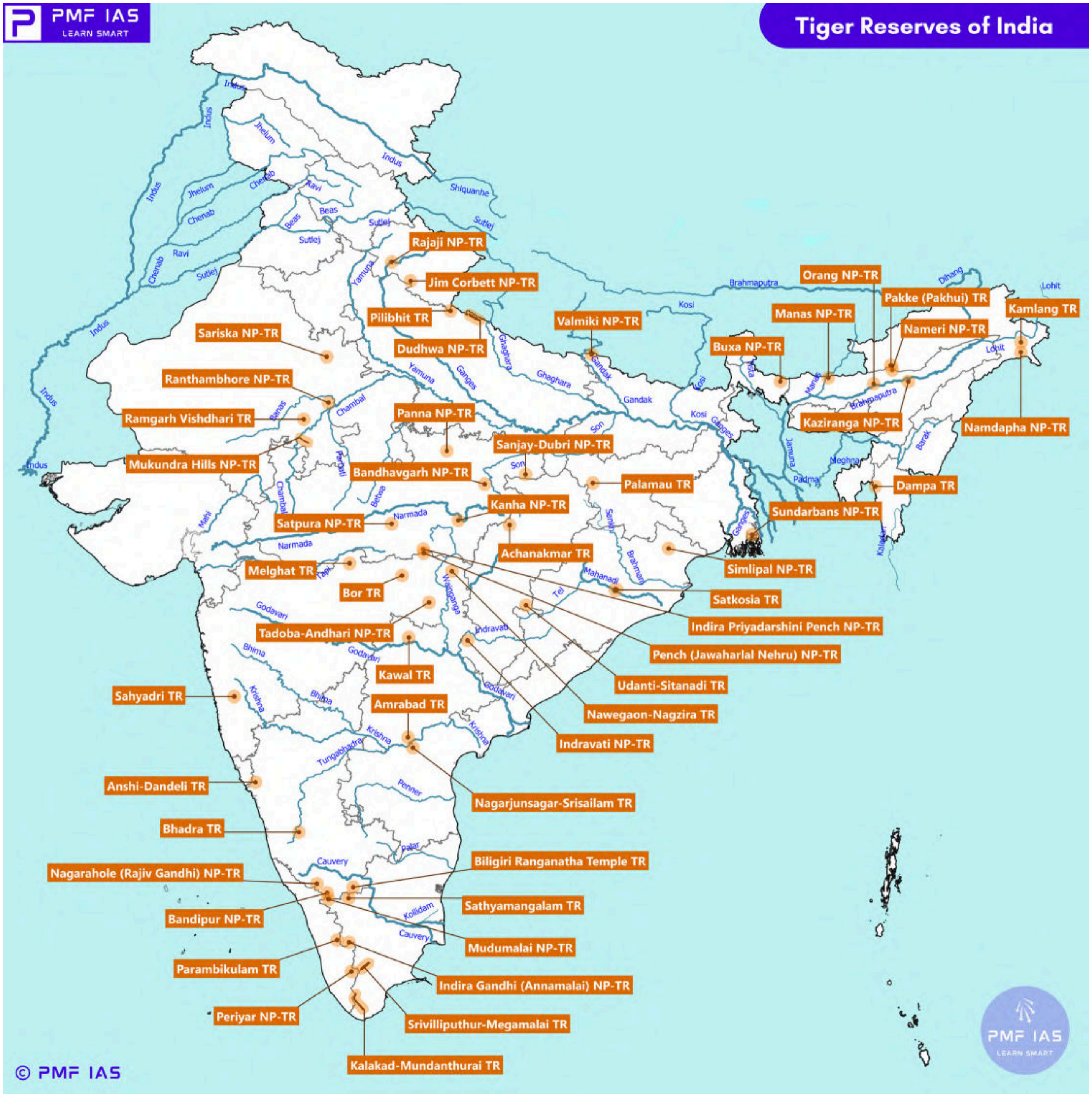
- Major Fauna: Bengal tiger, Indian leopard, clouded leopard, sloth bear, dhole, **Gangetic dolphin**, rhesus macaque, capped langur, Asian elephant, wild boar, sambar deer, hog deer, barking deer, etc.



Kaziranga Tiger Reserve, National Park

- It is a **World Heritage Site**.
- It is recognized as an **Important Bird Area** by **BirdLife International**.
- Vegetation: **terai marsh** with a vast expanse of **elephant grass** and dense tropical moist broadleaf forests.
- Threats: Floods and encroachment by people along the periphery.

Major Fauna

- The park hosts two-thirds (2,413) of the world's **great one-horned rhinoceroses (VU)**.

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- The **One-Horned rhinoceros, Royal Bengal Tiger, Asian elephant, wild water buffalo** and **swamp deer** are collectively known as **'Big Five' of Kaziranga**.
- **Kaziranga** has the **largest population of wild water buffalo (EN) anywhere**.
- Small herbivores include the **Indian muntjac**, wild boar, and hog deer.

Manas Tiger Reserve, National Park

- It is a **UNESCO Natural World Heritage site**, an **elephant reserve** and a **biosphere reserve**.
- It is contiguous with the **Royal Manas National Park in Bhutan**.
- Right branch of the **Manas river** passes through the heart of the national park.

Major Fauna

- The combination of **bhabar-terai** formation makes it one of the richest areas of biodiversity.
- Rare and EN endemic wildlife: **Assam roofed turtle (EN), hispid hare (EN), golden langur (EN) & pygmy hog (EN)**.
- Manas is famous for its population of the **wild water buffalo (EN)**.
- The grassland biomes: **pygmy hog, rhinoceros (reintroduced in 2007), elephants, Bengal florican (CR, Schedule I of WPA 1972, Appendix I of CITES, Appendix I of CMS)**, etc.
- The forest biomes: slow loris, capped langur, **golden langurs**, Assamese macaques, wild pig, sambar, **great hornbill**, black giant squirrel, **Chinese pangolin** etc.
- Other Major Fauna: barasingha, Indian tigers, Indian leopards, **clouded leopards**, Asian golden cats, dholes, sloth bears, barking deer, hog deer, **black panthers**, **sambar deer and chitals**.

Nameri Tiger Reserve, National Park

- Nameri shares its northern boundary with the **Pakke Tiger Reserve of Arunachal Pradesh**.
- Nameri Tiger Reserve has two core areas: **Nameri National Park** & **Sonai-Rupai Wildlife Sanctuary**.
- The **river Kameng** flows along the Southern boundary of the Park from North-West to South-East.
- Major Fauna: tiger, leopard, hog deer, sambar, dhole (the Asiatic wild dog), gaur, **clouded leopard (VU)**, barking deer, Marbled Cat, Himalayan black bear, capped langur, Indian giant squirrel, etc.
- Threats: logging, human-elephant conflict, poachers who hunt the valuable birds for their wings.

Rajiv Gandhi Orang Tiger Reserve, National Park

- The **river Dhanshiri** flows along the western edge of the park.
- **Orang park** is the **only stronghold of rhinoceros on the north bank of the Brahmaputra river**.
- Major Fauna: **The Great Indian rhinoceros (VU), pygmy hog (EN)**, Asian elephant, **wild water buffalo (EN)**, Bengal tiger, hog deer, **Gangetic dolphin (EN), Indian pangolin (EN)**, etc.
- Threats: Illegal occupation by immigrants from the neighbouring country, poaching, wide river channels.

Raimona National Park

- It is a part of the **Bodoland Territorial Region (BTR)**.
- It is the **6th national Park of Assam**.
- The area of the park includes the northern part of the notified **Ripu Reserve Forest**, which forms the **western-most buffer to the Manas National Park** that straddles the India-Bhutan border.
- It shares contiguous forest patches of **Phipsoo WLS** and **Jigme Singye Wangchuck National Park of Bhutan**.
- It is bounded on the west and the east by minor tributaries of Brahmaputra.
- Major Fauna: **golden langur (EN) (endemic to the region — named as the mascot of Bodoland region)**, Asian elephant, Royal Bengal tiger, **Clouded leopard (EN)**, Indian gaur, **Wild water buffalo**, Spotted deer, Hornbill, etc.

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37.3.5. Bihar

Valmiki Tiger Reserve, National Park, Wildlife Sanctuary

- It is located at the **India-Nepal border** in the West Champaran district of Bihar.
- Valmiki Tiger Reserve is an excellent example of **Himalayan Terai landscape**.
- **River Gandak** forms the western boundary of Valmiki wildlife sanctuary.
- It enters India at Valmikinagar. The river is called **'Narayani' in Nepal**.
- A river system originates from the Valmiki Forests and forms **Burhi Gandak River** down south.
- Major Fauna: **Bengal tiger, Indian rhinoceros**, **Indian flying fox**, black bear, Indian sloth bear, Indian leopard, barking deer, spotted deer, hog deer, sambar, flying squirrel, Clouded Leopard, Indian gaur, etc.
- **'Tharu'**, a scheduled tribe, is the dominant community in the landscape.

37.3.6. Chhattisgarh

Achanakmar Tiger Reserve, Wildlife Sanctuary

- It is a part of the **Achanakmar-Amarkantak Biosphere Reserve**.
- It is close to **Amarkantak** **(northeast of Maikal Hills in Satpura Range of Madhya Pradesh)**.
- **Amarkantak (in MP) is the source of the Son River** & **Narmada River**.
- The **Amarkantak in MP** & **Maikal Hills in Chhattisgarh** are the **meeting points** of **Vindhyas** & **Satpuras**.
- Vegetation: deciduous sal and bamboo forests.
- Major Fauna: Bengal tiger, Indian leopard, gaur, chital, sloth bear, sambar, **nilgai**, four-horned antelope, **chinkara**, blackbuck, Indian muntjac, etc.

Guru Ghasidas National Park

- The park is named after Guru Ghasidas of the **Satnami sect (sect similar to Sikhism)**.
- It is located in the Narmada Valley dry deciduous forests ecoregion.
- The part of the **Sanjay National Park (MP)** that is in Chhattisgarh is named Guru Ghasidas National Park.
- The **Sanjay-Dubri Tiger Reserve** comprises **Sanjay National Park (Madhya Pradesh)** and the **Dubri WLS**.
- Vegetation: sal, bamboo and mixed forests
- Major Fauna: The Bengal tiger, Indian leopard, spotted deer, sambar deer, wild boar, nilgai, chinkara, civet, porcupine, monitor lizard, etc.

Indravati Tiger Reserve, National Park

- It is located in the Bijapur district of Chhattisgarh.
- The park derives its name from the **Indravati River** (flows along the southern boundary of the reserve).
- Vegetation: tropical moist and dry deciduous type with predominance of bamboo, sal and teak.
- Major Fauna: **Wild Asian buffalo (EN)**, gaur (Indian bison), nilgai, blackbuck, chausingha (four-horned antelope), sambar, chital, Indian muntjac, tigers, flying squirrel, pangolins, rhesus monkeys, etc.

Kanger Valley National Park

- It is home to the **Bastar hill myna**, the **state bird of Chhattisgarh**.
- The park derives its name from the **Kanger River**, which flows throughout its length.
- It has huge **limestone deposits** where some of them are in the form of caves like the **Kotumsar Caves**.
- Vegetation: Sal, teak and bamboo.
- Major Fauna: tigers, leopards, mouse deer, wild cat, chital, sambar, barking deer, rhesus macaque, sloth bear, flying squirrel, crocodiles, monitor lizards, etc.

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Udanti-Sitanadi Tiger Reserve

- **Udanti-Sitanadi Tiger Reserve** = **Sitanadi WLS + Udanti WLS**
- **Sitanadi River (a tributary of Mahanadi)** originates and flows through Sitanadi WLS.
- **Udanti River (tributary of Tel River — a tributary of Mahanadi)** flows through Udanti WLS.
- Vegetation: tropical dry peninsular sal forests and tropical dry deciduous mixed forests.
- Major Fauna: tiger, **wild water buffalo (EN)**, chital, sambar, four-horned antelope, barking deer, etc.

37.3.7. Goa

Mollem National Park and Bhagwan Mahaveer Sanctuary

- **National Highway 4A** divides the park into two parts.
- It is home to waterfalls, such as **Dudhsagar Falls** and Tambdi Falls.
- The parkland is also home to a community of nomadic buffalo herders known as the **Dhangar**.
- **Dudhsagar Falls** is a tiered waterfall on the **Mandovi River** at the Karnataka border.
- At 310 m, it is Goa's tallest waterfall and India's fifth tallest.

- Major Fauna: leopard, barking deer, Bengal tiger, bonnet macaque, civet, flying squirrel, gaur, Malabar giant squirrel, mouse deer, pangolin, porcupine, slender loris, sambar, spotted deer, wild boar, etc.
- Threats: **surface mining** and transport of manganese and iron ores.

37.3.8. Gujarat

Blackbuck (Velavadar) National Park

- Vegetation: savanna grassland.
- Major Fauna: blackbucks, wolves, Macqueen's bustards, hyenas and lesser floricans, etc.
- Conservation programs for the **blackbuck** and **lesser florican (a bustard – EN)** are ongoing.

Gir National Park and Wildlife Sanctuary

- Today, it is the only area in Asia where **Asiatic lions** occur.
- In 2015, the population of Asiatic lions was 523 (27% up compared to previous census in 2010).
- The lion population is highest in **Junagadh District** (268 individuals).
- **Kamleshwar Dam** situated in the park is 'the lifeline of Gir'.
- Vegetation: dry deciduous scrub forest. Teak and acacia are found.
- Major Fauna: **Asiatic lion (EN)**, **mugger crocodile (VU)**, Indian leopard, striped hyena, Golden jackal, chital, nilgai, sambar, four-horned antelope, chinkara, wild boar, blackbuck, etc.

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Marine (Gulf of Kachchh) National Park

- Major Fauna: **Corals**, sea turtles such as green sea turtles, **olive ridleys (VU)** and **leatherbacks**, **dugongs (sea cow – VU)**, common dolphins, Indo-Pacific humpback dolphins, etc.
- Threats: extraction of corals and sands by cement industries, increased turbidity of water, oil refineries, chemical industries, and mechanized fishing boats.

Vansda (Bansda) National Park

- Location: **Sahyadri range in the Western Ghats**.
- The Ambika River separates the Vansda National Park from the **Purna Wildlife Sanctuary**.
- Vegetation: deciduous forest with teak, bamboo, sisam trees.
- Major Fauna: Indian leopard, rhesus macaque, Hanuman langur, small Indian civet, four-horned antelope, Indian porcupine, barking deer, flying squirrel, **Indian giant squirrel (Malabar giant squirrel)** etc.

37.3.9. Haryana

Kalesar National Park

- The Kalesar NP and the Kalesar WLS are contiguous to **Simbalbara National Park** in **Himachal Pradesh**.
- The Kalesar NP is bounded by **Yamuna River** to the east, **Rajaji National Park** in **Uttarakhand** to the northeast and **Simbalbara National Park** to the north.
- This forested area in the **Shivalik foothills** is covered primarily with sal.
- Major Fauna: leopards, panthers, rusty-spotted cat, Asiatic elephant, chital, sambar, barking deer, goral, nilgai, Indian crested porcupine, small Indian civet, rhesus macaque, etc.

Sultanpur National Park

- Sultanpur National Park (formerly Sultanpur Bird Sanctuary) is 15 km from **Gurugram**, Haryana.
- The park hosts a large number of migratory birds.

37.3.10. Himachal Pradesh

Great Himalayan National Park

- It is located near the **Kullu Valley (Beas River flows along the valley)** at an altitude of 1500-6000 m.
- It is a **UNESCO World Heritage Site**.
- Vegetation: temperate to subalpine.
- Major Fauna: **Blue sheep**, **snow leopard (VU), Himalayan brown bear, Himalayan tahr**, etc.

Inderkilla National Park

- It is located in the **Kullu district**.
- It is less than 50 km away from the picturesque **Kullu Valley**.
- The **Chenab River** flows just a few kilometres to the north of the park.
- Major Fauna: black bear, common leopard, **Himalayan Ibex** (Siberian Ibex), etc.

Khirganga National Park

- The park is flanked by the **Great Himalayan National Park (GHNP)** and **Pin Valley National Park**.
- Vegetation: dry alpine and scrub.
- Major Fauna: **Snow Leopard, Himalayan Ibex, blue sheep**, Himalayan Brown Fox, etc.

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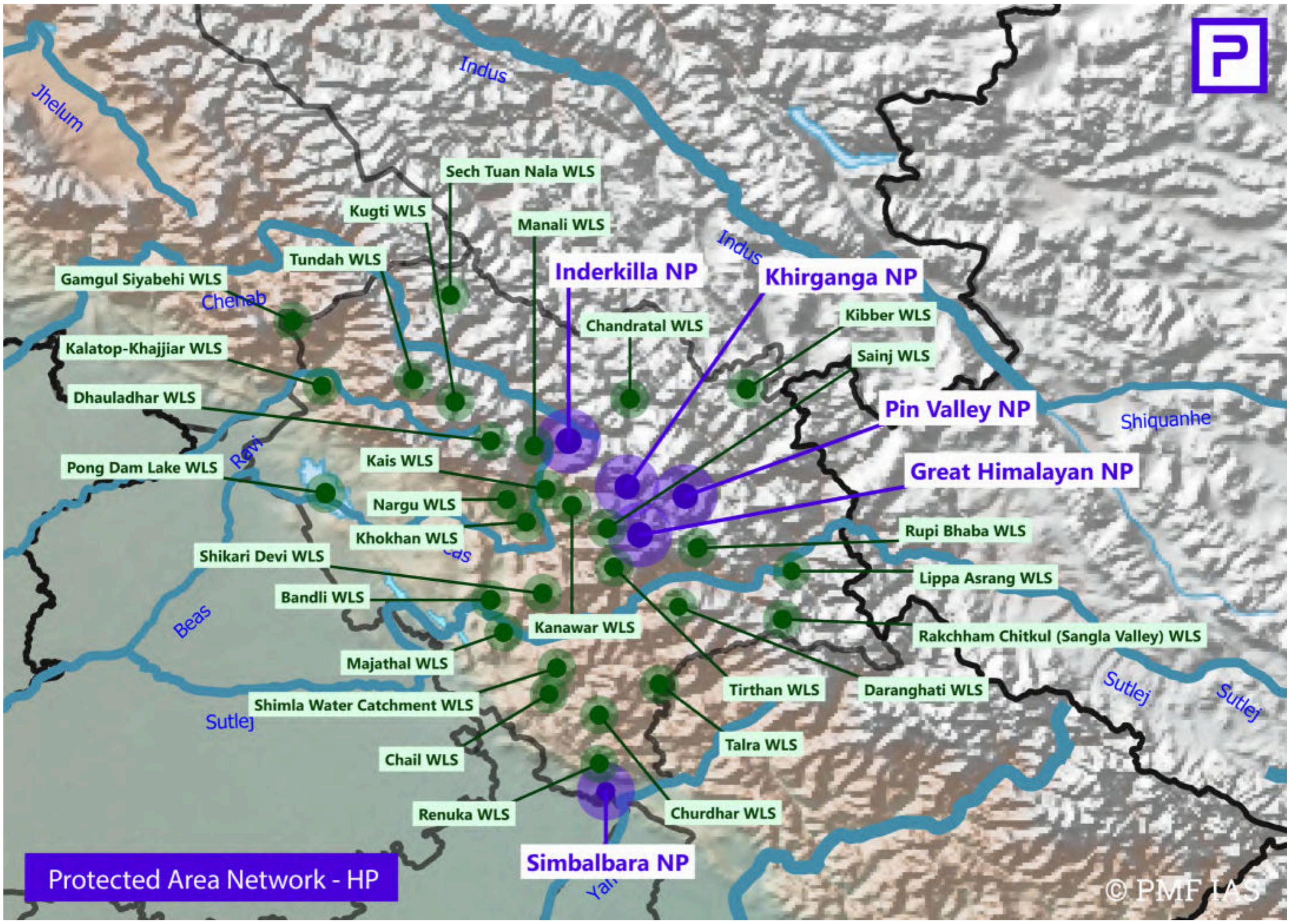
Pin Valley National Park

- It is located in the **desert habitat of the Pin Valley** **(tributary valley of the Spiti Valley – Lahaul & Spiti district)**.
- The Pin River drains into the **Spiti River (a tributary of Sutlej)**.
- The elevation of the park ranges from about 3,500 metres to more than 6,000 metres.
- Vegetation density is sparse, consisting mostly of alpine trees and groves of Himalayan cedar.
- Major Fauna: **Snow Leopard** and **Himalayan Ibex** (also referred to as **Siberian Ibex**).

Simbalbara National Park

- It is located at the **confluence of Terai plains with the Shivaliks**.
- Vegetation: mixed deciduous **Sal forests**.
- Major Fauna: leopard, sambhar, goral, chital, barking deer, spotted deer, nilgai (blue bull), etc.



37.3.11. Jammu & Kashmir

City Forest (Salim Ali) National Park

- It is located in **Srinagar**.
- The name of the park commemorated the Indian **ornithologist** **Salim Ali**.
- Major Fauna: **Kashmiri stag (hangul – CR), musk deer**, Himalayan black bear, etc.

Salim Ali (1896-1987)

- Salim Ali is the most widely revered **Indian ornithologist**.
- Salim Ali was the first Indian to conduct systematic bird surveys across India.

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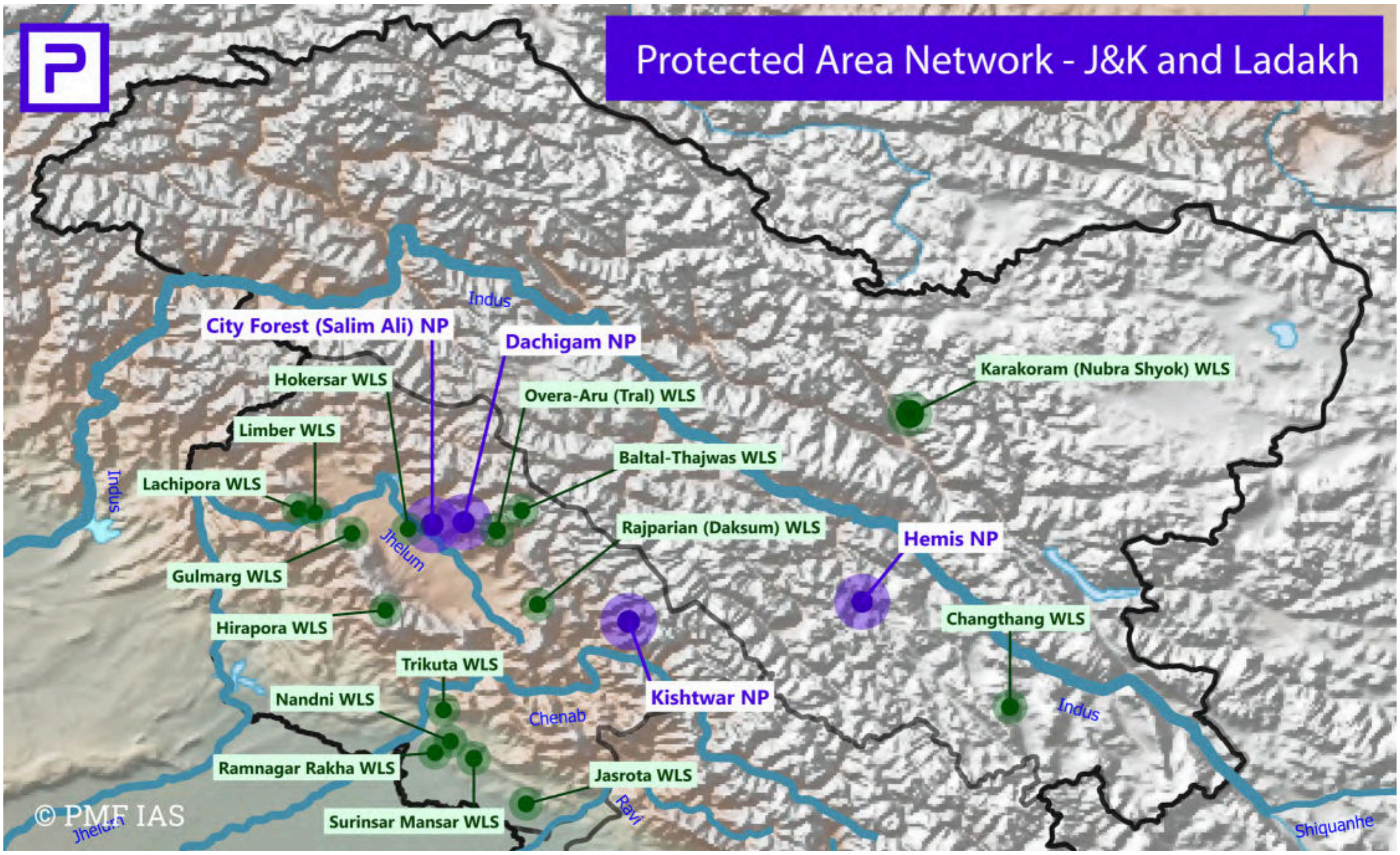
- He became a key figure behind the **Bombay Natural History Society**.
- He was instrumental in the creation of the **Bharatpur bird sanctuary (Keoladeo National Park)**.
- He was awarded the Padma Bhushan and the Padma Vibhushan.

Dachigam National Park

- It is located about 20 kilometres to the east of **Srinagar** in the **Zabarwan Range**.
- Vegetation: coniferous forest, alpine pastures, and meadows.
- Major Fauna: **Hangul (Kashmir stag), Musk deer (EN)**, Leopard, Himalayan serow, Kashmir grey langur, Himalayan black bear, Himalayan brown bear, etc.

Kishtwar National Park

- It is situated in the Kishtwar district, Jammu and Kashmir.
- The altitude varies from 1700 to 4800 Metres.
- Major Fauna: Snow Leopards, Himalayan snowcock, brown bear.
- Vegetation: conifer forests (Fir, Himalayan Yew, Deodar, Pine, Spruce), alpine scrub and meadows.



37.3.12. Ladakh

Hemis National Park

- It is a high-altitude national park in the eastern Ladakh Union Territory.
- It is globally famous for its **snow leopards (VU)**.
- It is the **only national Park in India that is to the north of the Greater Himalayas**.
- The park is bounded on the **north by the banks of the Indus River**, and on the south by the parts of the **Zanskar Range**.

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- Vegetation: pine forests, alpine shrublands and meadows, and alpine tundra.
- Major Fauna: snow leopards, argali (**Tibetan Sheep**), **bharal (Blue Sheep)**, shapu (Ladakhi Urial), etc.
- Avian Major Fauna: Trans-Himalayan such as the golden eagle, **Himalayan griffon vulture**, etc.
- Threats: man-animal conflict due to pastoralists raising goats, and sheep and overgrazing of livestock.

37.3.13. Jharkhand

Betla National Park and Palamu Tiger Reserve

- It is located on the **Chota Nagpur Plateau** in the **Palamu district**.
- It comprises the **Palamu Tiger Reserve**.
- The **North Koel River** (a **tributary of Son River**) flows through the northern portion of the park.
- Vegetation: bamboo and sal forests.
- Major Fauna: **elephants, Bengal tiger**, sloth bear, gaur, chital, sambhar, nilgai, mouse deer, rhesus monkeys, Indian giant squirrels, sambhar deer, four-horned antelopes, pangolin, etc.

Palamu Tiger Reserve

- It is **one of the nine original tiger reserves in India**.
- It forms part of **Betla National Park** and **Palamu Wildlife Sanctuary**.
- The **North Koel River** runs through the reserve.

37.3.14. Karnataka

Anshi National Park and Dandeli-Anshi Tiger Reserve

- It adjoins the **Dandeli wildlife sanctuary**.
- It is located in an eco-sensitive part of the Western Ghats, and the altitude varies from 200 m to 925 m.
- Vegetation: montane rain forests and moist deciduous forests.
- Major Fauna: **elephant (EN), Bengal tiger (EN)**, **black panther (black colour variant of leopard (VU))**, wild boars, **bonnet macaque, Malabar civet, Malabar giant squirrel**, deer, Indian bison, pangolin, sloth bear, barking deer (muntjac), mouse deer (chevrotain), sambar deer and spotted deer (chital), etc.

Kali Tiger Reserve (Dandeli-Anshi Tiger Reserve)

- **Anshi National Park** and **Dandeli Wildlife Sanctuary** were together granted the status of Project Tiger.
- The **Kali River** (west-flowing) flows through the tiger reserve.

Bandipur Tiger Reserve, National Park

- Together with the adjoining **Nagarhole National Park**, **Mudumalai National Park (Tamil Nadu)** and **Wayanad Wildlife Sanctuary (Kerala)**, it is part of the **Nilgiri Biosphere Reserve**.
- The **Kabini river (a tributary of the Cauvery River)** separates **Bandipur NP** from **Nagarhole NP**.
- Bandipur NP is contiguous with the **Mudumalai NP** (Tamil Nadu) and **Wayanad WLS (Kerala)**.
- Vegetation: dry deciduous forest, moist deciduous forests and shrublands.
- Major Flora: teak, rosewood, **sandalwood** (Veerappan's favourite), clumping bamboo, etc.
- Major Fauna: **Indian elephants**, gaurs, tigers, sloth bears, four-horned antelopes, dholes, chital, sambar, gray langurs, Indian giant squirrels.
- Threats: wildlife fatalities caused by speeding vehicles, cattle grazing & transmission of diseases from cattle to wildlife, deforestation and habitat fragmentation, man-animal conflict, and invasive species such as **Lantana (bush is thorny and is not eaten by any herbivores)** and **Parthenium**.
- There is a ban on traffic from 9 pm to 6 am of dusk to dawn to help bring down the death rate of wildlife.

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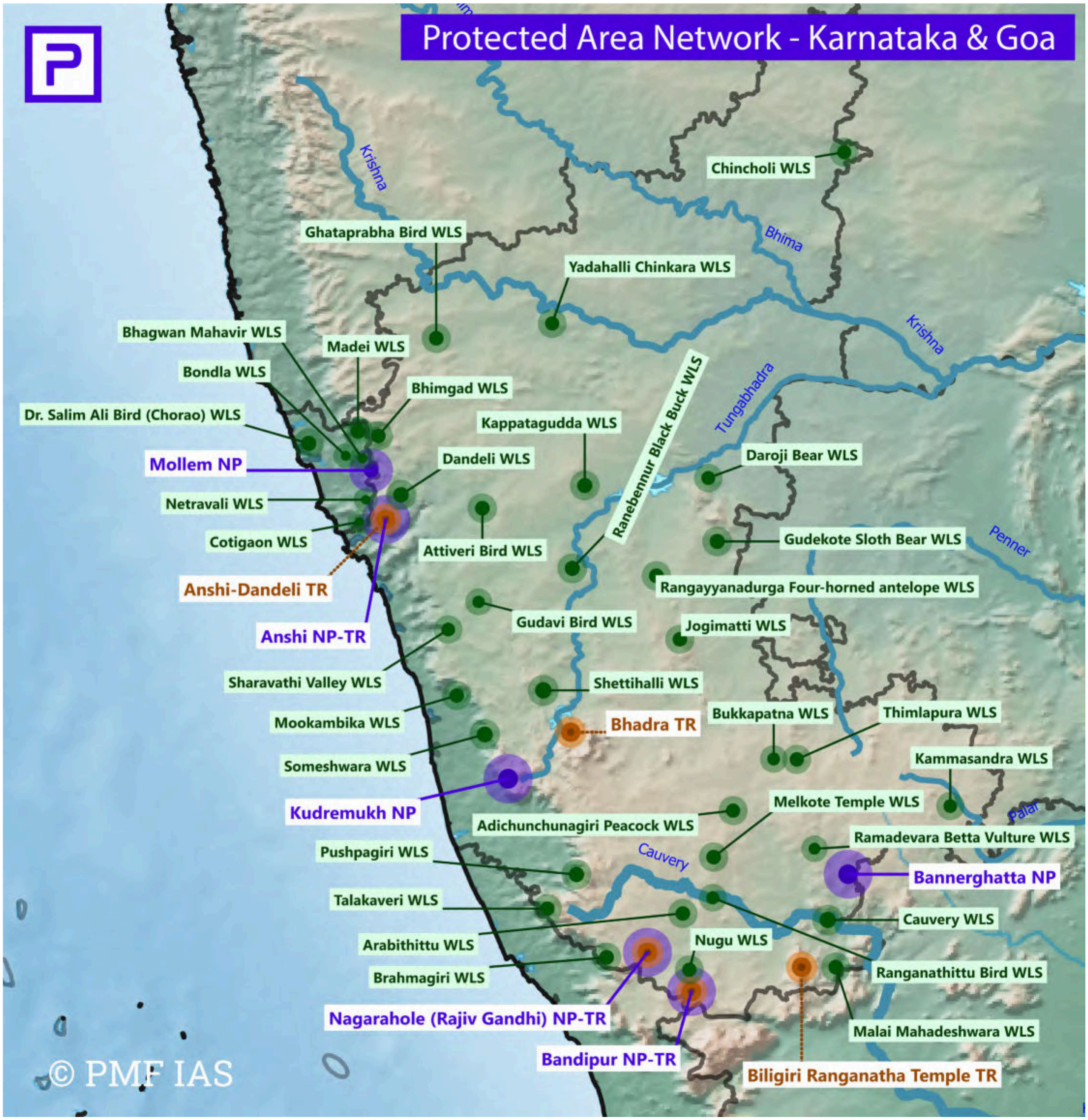

Bannerghatta National Park

- It is **near Bangalore**.
- It is part of a wildlife corridor for elephants which connects the **BR Hills** and the **Sathyamangalam forest**.
- Major Fauna: elephants, Bengal tiger, gaur, leopard, sloth bear, Indian gazelle, spotted deer, barking deer, common langur, bonnet macaque, porcupine, wild boar, pangolin, etc.
- A portion of the park is converted into **Bannerghatta Biological Park**.
- The Biological Park has a zoo, a butterfly enclosure, a snake house and a safari park.
- The Biological park shelters mammals such as Indian tigers (including white tigers) and lions.
- Threats: illegal mining of granite close to **critical elephant corridors** inside the national park.

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Bhadra Tiger Reserve, Wildlife Sanctuary

- It is about 100km to the east of **Kudremukh National Park**.
- Elevation varies from 615 m to 1,875 m.
- Vegetation: semi-evergreen forests, moist deciduous forests, and shola grasslands on the uplands.
- The sanctuary is surrounded by scenic hills, including the **Baba Budangiri hills**.
- **Mullayanagiri peak** (1,930 m) in the hills is the highest peak between the Himalayas and the Sub-Cluster.
- **Hebbe Falls** and **Manikyadhara Falls** are located on the periphery of the sanctuary.
- Major Fauna: tiger, leopard, gaur, sambar, wild pig, Malabar civets, **Malabar giant squirrel**, spotted deer, muntjac, chevrotain, bonnet macaque, common langur, **lion-tailed macaque (EN)**, etc.
- Threats: iron ore mining, tourism and related construction, tribal population in the park, etc.

Biligiri Ranganatha Temple Tiger Reserve, Wildlife Sanctuary

- It is the **starting point of Eastern Ghats**.
- The **Biligiri Hills (BR Hills)** along with the **Male Mahadeshwara Hills, Bannerghatta, Sathyamangalam Reserve Forest** form an important **wildlife corridor between the Western Ghats and the Eastern Ghats**.
- Vegetation: deciduous, evergreen, sholas and grasslands.
- Major Fauna: wild elephants, tiger, gaur, sambhar, chital, barking deer, etc.
- Threats: quarrying, sandalwood smuggling, elephant poaching, etc.

Kudremukh National Park

- The **Tunga River** and **Bhadra River** flow through the parklands.
- The Kudremukh range is proposed to be declared a tiger reserve as part of the **Bhadra Tiger Reserve**.
- Vegetation: semi-evergreen forests, moist deciduous forests, and shola grasslands on the uplands.
- Major Fauna: tiger, leopard, gaur, sambar, wild pig, Malabar civets, Malabar giant squirrels, wild dogs, sloth bears, spotted deer, muntjac, chevrotain, bonnet macaque, common langur, **lion-tailed macaque**, etc.
- Threats: **iron ore mining**, tourism and related construction, tribal population in the park, etc.

Nagarahole (Rajiv Gandhi) Tiger Reserve, National Park

- It is located in **Kodagu district and Mysore district**.
- It is recognized as an **Important Bird Area**.
- **Jenu Kurubas** (honey collecting tribes) live in this park.
- Vegetation: moist deciduous forests, dry deciduous forests, montane valley swamp forests, bamboo etc.
- Major Flora: commercially important **rosewood, teak, sandalwood** and **silver oak**.
- Major Fauna: Bengal tiger, Indian leopard, Indian elephant, dhole, sloth bear, striped hyena, chital, sambar deer, barking deer, four-horned antelope, gaur, **mugger (marsh crocodile) in Kabini**, etc.
- Threats: tourism, fragmentation of forest ranges and human-wildlife conflicts, poaching (tribal communities deprived of their traditional ways of life are indulging in poaching activities).
- In 2020, the pictures of **rare black panther** Saya caught on camera by photographer Shaaz Jung from the dense forests of **Nagarhole** went viral.

Q. Which of the following Protected Areas are located in the Cauvery basin?

1. Nagarhole National park
2. Papikonda National park
3. Sathyamangalam Tiger Reserve
4. Wayanad Wildlife sanctuary

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Select the correct answer using the code given below:

a) 1 and 2 only

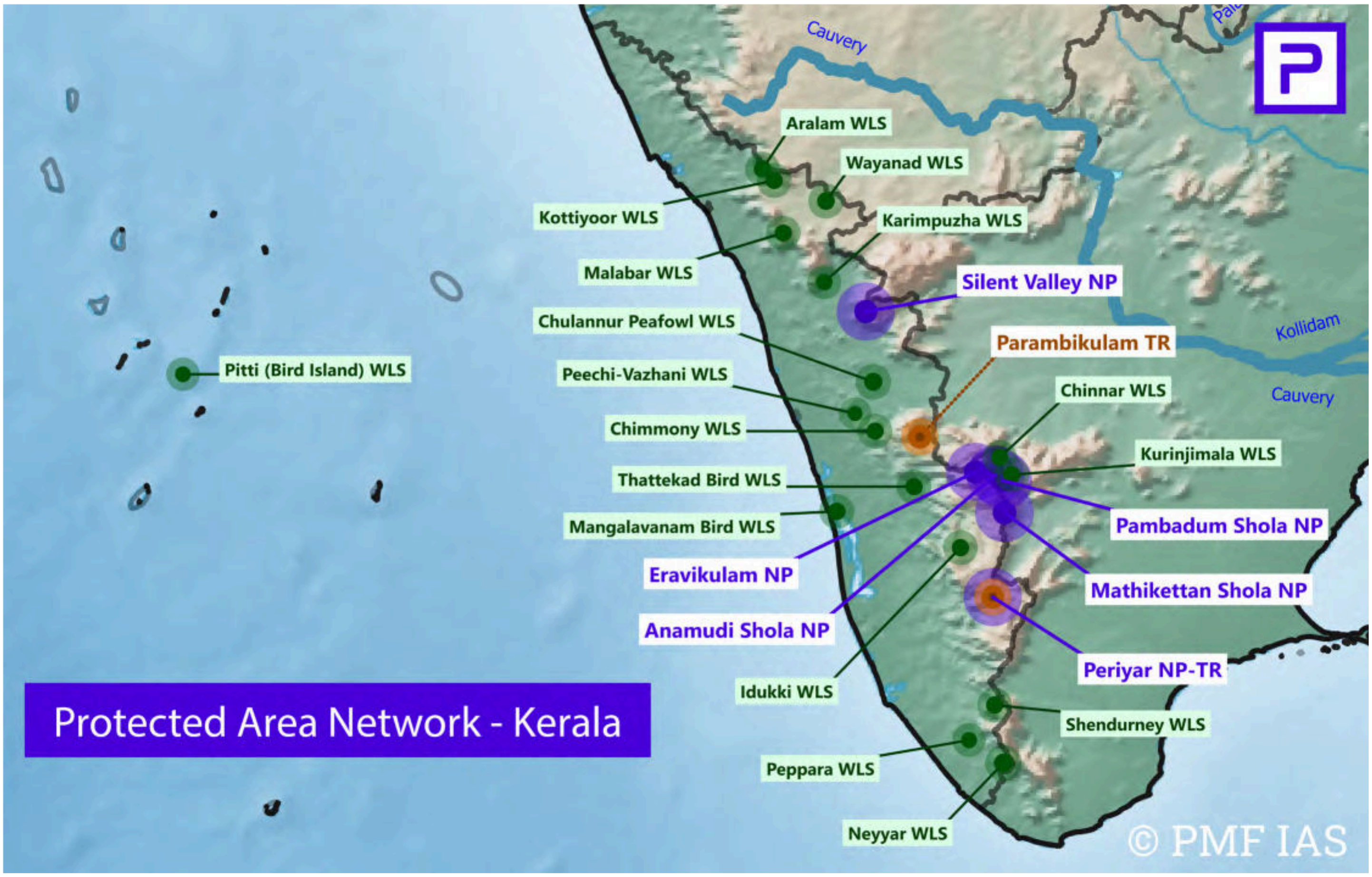
b) 3 and 4 only

c) 1, 3 and 4 only

d) 1,2,3 and 4

Answer: (Hill in Kannada → Betta; Telugu → Konda; Tamil → Malai); c) All except Papikonda NP

37.3.15. Kerala



Anamudi Shola National Park

- It is located in the Western Ghats at an altitude ranging about 2000 m.
- **Anamudi (2695), the highest peak in peninsular India**, is located in this Park and **Eravikulam NP**.
- It is surrounded by **Mathikettan Shola NP, Eravikulam NP, Pambadum Shola NP, Chinnar WLS,** and the **Kurinjimala WLS**. (All these are part of **Munnar Wildlife Division** in **Idukki District**).
- Vegetation: tropical evergreen forests, wet montane forests, moist deciduous forests and shola forests.
- Major Fauna: **lion-tailed macaques, Nilgiri tahr (EN), Nilgiri marten (VU)**, gaur, muntjac, **giant grizzled squirrel (NT)**, flying squirrels, **Nilgiri langur (VU)**, etc.
- Threats: tourism-related construction, invasive species, severe deforestation to make way for **plantation crops** like rubber, tea, coffee, spices, etc.

Sholas

- The Shola vegetation are **tropical montane forests found in the Western Ghats separated by rolling grasslands in high altitudes** (upper Nilgiris with peaks and plateaus ranging from 1,700 to 2,600 metres).

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- The shola woods house a dense patch of **stunted trees** with the presence of **lichen, mosses, and climbers**.
- Owing to the altitude, the Shola patches occur **only in the folds of the mountains that receive the least fog**.

Eravikulam National Park

- It consists of a high rolling hill plateau with a base elevation of about 2,000 m.
- Vegetation: high altitude grasslands interspersed with sholas.
- Major Fauna: similar to Anamudi Shola National Park.

Mathikettan Shola National Park

- Similar to Anamudi Shola National Park.

Pambadum Shola National Park

- The park adjoins the proposed **Palani Hills WLS** and National Park (Tamil Nadu).
- It is a part of **Palani hills of Kerala**.
- Similar to Anamudi Shola National Park.

Parambikulam Tiger Reserve

- It is located in **Palakkad district** between the **Anaimalai Hills (TN)** and **Nelliampathy Hills (Kerala)**.
- Altitude ranges between 300 m and 1438 m.
- Major Fauna: **lion-tailed macaques**, Nilgiri tahr, elephants, Bengal tigers, Indian leopards, wild boar, sambar, bonnet macaques, Nilgiri langurs, sloth bears, **Nilgiri marten**, small **Travancore flying squirrel**, gaur, etc.
- Vegetation: evergreen, moist deciduous, shola, etc.

Periyar Tiger Reserve, National Park, Elephant Reserve

- It is located in the districts of Idukki and Pathanamthitta.
- It forms the major watershed of two important rivers of Kerala, the **Periyar** and the **Pamba**.
- The park is located in the **Cardamom Hills** of the Western Ghats along the border with Tamil Nadu.
- The park surrounds **Periyar Lake**.
- Periyar Lake became a reservoir in 1895 after the **Mullaperiyar Dam** was erected.
- The dam is built at the confluence of **Mullayar** and **Periyar rivers**.
- **The dam is in Kerala** on the **river Periyar** **but is operated and maintained by Tamil Nadu**.
- Vegetation: tropical evergreen and moist deciduous forests, grasslands and stands of eucalyptus.
- Major Flora: teak, rosewoods, sandalwoods, eucalyptus, bamboos, etc.
- Major Fauna: Bengal tiger, elephant reserve, gaur, sambar, Indian giant squirrel, Travancore flying squirrel, jungle cat, sloth bear, Nilgiri tahr, lion-tailed macaque, Nilgiri langur, Salim Ali's fruit bat, Nilgiri marten, etc.
- Major Avian Fauna: endemic Malabar grey hornbill, Nilgiri wood pigeon, etc.

Silent Valley National Park

- Location: **Nilgiri Biosphere Reserve**; to the south-west of **Mukurthi National Park**.
- Vegetation: South Western Ghats mountain rain forests and tropical moist evergreen forest. Above 1,500 m, the evergreen forests begin to give way to stunted forests, called sholas, interspersed with open grassland.
- Major Fauna: **Lion-tailed macaques (EN)**, Niligiri langur, Malabar giant squirrel, Nilgiri tahr, tiger, leopard, mall Travancore flying squirrel, Indian pangolin, etc.
- **Silent Valley** is home to the **largest population of lion-tailed macaques (EN)**.
- Threats: livestock grazing and forest fires, illegal plantations of cannabis, etc.

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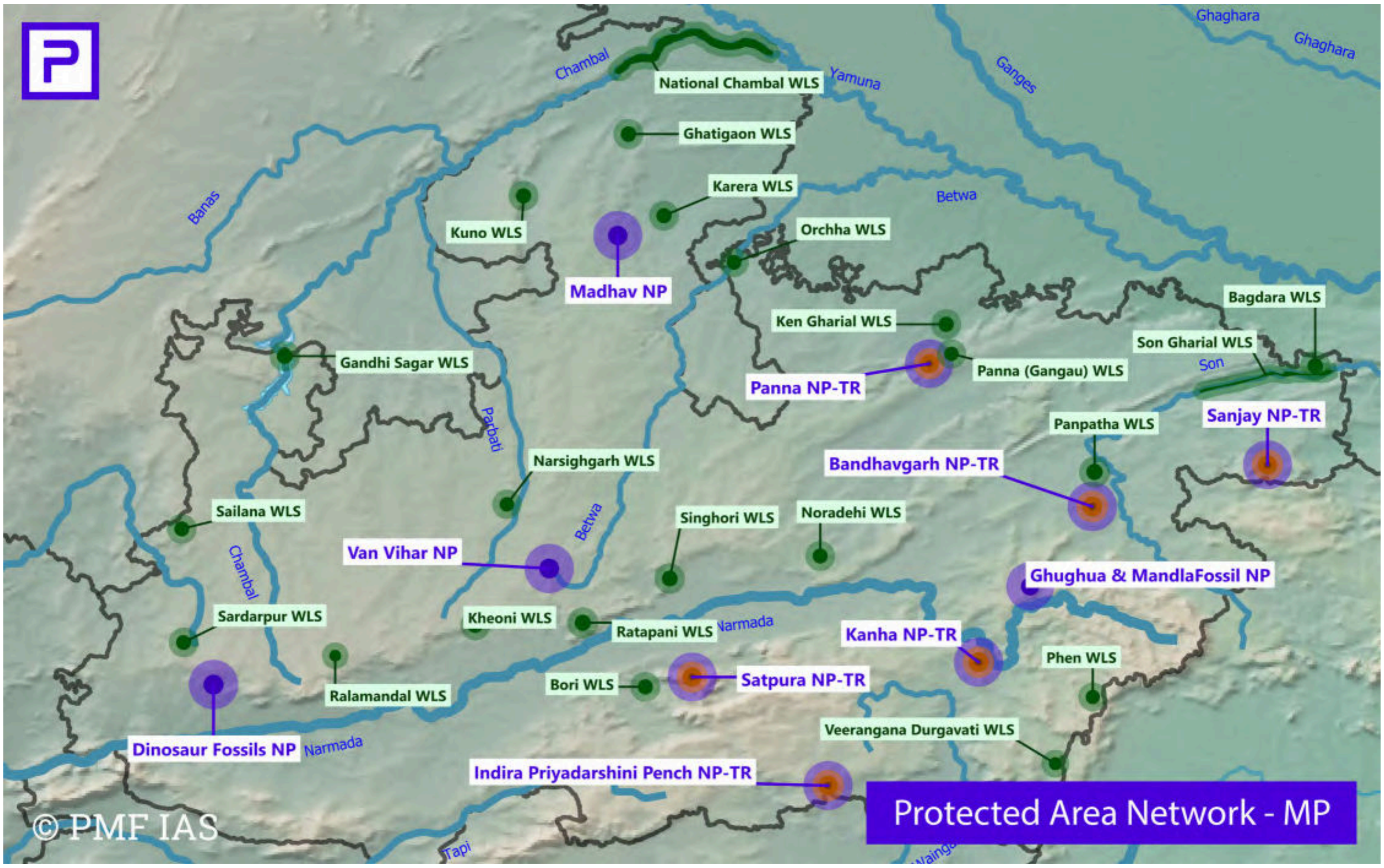
37.3.16. Madhya Pradesh



Bandhavgarh Tiger Reserve, National Park

- It is spread at **Vindhyas** in Madhya Pradesh.
- It was the former hunting preserve of the Maharaja of Rewa.
- **India's first white tiger** was captured in this region in 1951.
- **The density of the tiger population at Bandhavgarh is one of the highest known in India**.
- Vegetation: moist deciduous forests and mixed deciduous forest and **sal forests**.
- Major Fauna: Bengal tiger, elephant, leopard, sambar, barking deer, Indian wolf, striped hyena, nilgai, etc.
- The **Indian bison** were **reintroduced from Kanha**.

Dinosaur (Ashmadha) Fossils National Park

- It is located in the **Narmada Valley** in Dhar District, about 80 km away from the city of **Indore**.
- **Dinosaur eggs and fossils** and fossilized trees dating back 60 million years were discovered in the site.

Indira Priyadarshini Pench Tiger Reserve, National Park

- Location: southern reaches of the **Satpura range**.
- It derives its name from the **Pench River** (emerges from **Mahadeo Hills**) that flows through the park from north to south, dividing the park into equal halves.
- **Pench Tiger Reserve** straddles across **Madhya Pradesh (1180 km^2)** and **Maharashtra (740 km^2)**
- It comprises the **Indira Priyadarshini Pench National Park** and the **Pench Mowgli Sanctuary**.
- **Pench Tiger Reserve in Madhya Pradesh recorded the highest number of tigers (Census 2018)**.
- The **NH 44 (old NH 7)**, runs along the eastern boundary of the reserve for around 10 km.

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- Vegetation: dry deciduous forests with **teak** and other species.
- Major Fauna: Royal Bengal tiger, Indian leopard, sloth bear, gaur, four-horned antelope, barking deer, wild dog, wild boar, chital, sambar, etc.
- Threats: poaching, habitat loss and fragmentation (e.g., **widening of NH44**), etc.

Kanha Tiger Reserve, National Park

- Location: **Maikal range of Satpuras** (Central Indian highlands).
- The forests are the inspiration for Rudyard Kipling's "The Jungle Book".
- Tribes displaced from the region: **Baiga tribes** **(lost their forest rights** & were not properly compensated).
- Vegetation: tropical dry deciduous.
- Major Flora: Sal, bamboo forests.
- Major Fauna: Royal Bengal tiger, gaur, **barasingha (swamp deer – VU)**, Indian wild dog (dhole), spotted deer, sambar, barking deer, four-horned antelope, etc.

Q. Which one of the following protected areas is well-known for the conservation of a sub-species of the Indian swamp deer (Barasinga) that thrives well in hard ground and is exclusively graminivorous (grass eating)?

a) Kanha National Park
b) Manas National Park
c) Mudumalai Wildlife Sanctuary
d) Tal Chhapar Wildlife Sanctuary

Answer: a)

Madhav National Park

- It was named after Madho Rao Scindia belonging to the Scindia dynasty of the Marathas.
- Vegetation: dry deciduous forests.
- Major Fauna: **chinkara (Indian gazelle)**, chital, nilgai, sambar, chausingha (four-horned antelope), etc.
- **Sakhya Sagar** and **Madhav Sagar lakes** are two important biodiversity support systems in the park.

Mandla Plant Fossil National Park

- It is situated in the **Narmada Valley** in Mandla district.
- This National Park has plants in fossil form that existed in India anywhere between 40-150 million years ago.
- **Ghughua Fossil Park** is just a few kilometres from Mandla Plant Fossil National Park.

Panna Tiger Reserve, National Park

- **Panna National Park** along with **Ken Gharial Wildlife Sanctuary,** form a significant part of the catchment area of the **Ken River (a tributary of Yamuna)** which runs northeast through the park.
- In the **Ken Gharial Sanctuary, gharials (CR fish-eating freshwater crocodiles)** are bred in captivity and then released.
- Vegetation: fragmented deciduous forests.
- Major Fauna: tiger, leopard, chital, chinkara, nilgai, sambhar and sloth bear.
- In 2012, there were no tigers left in the reserve.
- A tiger each from **Bandhavgarh NP** and **Kanha NP** were translocated to **Panna Tiger Reserve**.

Sanjay National Park, Sanjay-Dubri Tiger Reserve

- The part of the Sanjay National Park that is in Chhattisgarh is named **Guru Ghasidas National Park**.
- The **Sanjay-Dubri Tiger Reserve** comprises **Sanjay NP (Madhya Pradesh)** and the Dubri WLS.

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- It is located in the Narmada Valley dry deciduous forests.
- Vegetation: Sal, Bamboo and mixed forests
- Major Fauna: the Bengal tiger, Indian leopard, spotted deer, sambar deer, wild boar, nilgai, chinkara, civet, porcupine, monitor lizard, etc.

Satpura Tiger Reserve, National Park

- Location: **Satpura range**.
- The altitude ranges from 300 to 1,300 metres.
- The terrain is rugged and consists of sandstone peaks, gorges, ravines and dense forests of sal and teak.
- Major Fauna: Bengal tiger, leopard, sambar, chital, Indian muntjac, nilgai, four-horned antelope, chinkara, wild boar, bear, blackbuck, flying squirrel, Indian giant squirrel, etc.

Van Vihar National Park

- It is a **zoological Park** in **Bhopal city**.
- **Captive Fauna**: Bengal tiger, Asiatic lion, **mugger crocodile, gharial**, cheetal (spotted deer), sambhar, blackbuck, nil-gai, chausingha, rhesus macaque, etc.

37.3.17. Maharashtra

Bor Tiger Reserve, Wildlife Sanctuary

- It is located in Wardha District and includes the drainage basin of the **Bor Dam**.
- Vegetation: dry deciduous forests with teak and bamboo.
- Major Fauna: Bengal tiger, Indian leopard, Indian bison, blue bull, chital, sambar deer, peacock, barking deer, mouse deer, etc.
- Threats: the biggest threat to Bor is forest fires and human-animal conflict.

Melghat Tiger Reserve, Gugamal National Park

- **Gugamal National Park** is part of **Melghat Tiger Reserve**.
- The **Tapi River** flows along the northern end of the Melghat Tiger Reserve.
- The **Gawilgarh Hills** flank the reserve on the western side.
- Vegetation: dry deciduous forest.
- Major Fauna: Bengal tiger, Indian leopard, sloth bear, chausingha, sambar, gaur, barking deer, flying squirrel, cheetal, nilgai, rhesus monkey, etc.

Nawegaon National Park

- Navegaon National Park is an **important bird area**.
- In winter, flocks of migratory birds visit **Nawegaon lake**.
- Vegetation: moist deciduous forest and dry deciduous forest.
- Major Fauna: tiger, leopard, Indian gaur, sloth bear, common giant flying squirrel, small Indian civet, palm civet, mouse deer, spotted deer, four-horned antelope, sambar, dhole, blue bull etc.

Nawegaon-Nagzira Tiger Reserve

- **Navegaon Nagzira Tiger Reserve = Nawegaon NP + Nagzira WLS + Koka WLS**.

Pench (Jawaharlal Nehru) National Park

- **Indira Priyadarshini Pench NP is in MP**, and **Jawaharlal Nehru Pench NP is in Maharashtra**.
- **Pench Tiger Reserve** straddles across **Madhya Pradesh (1180 km^2)** and **Maharashtra (740 km^2)**.

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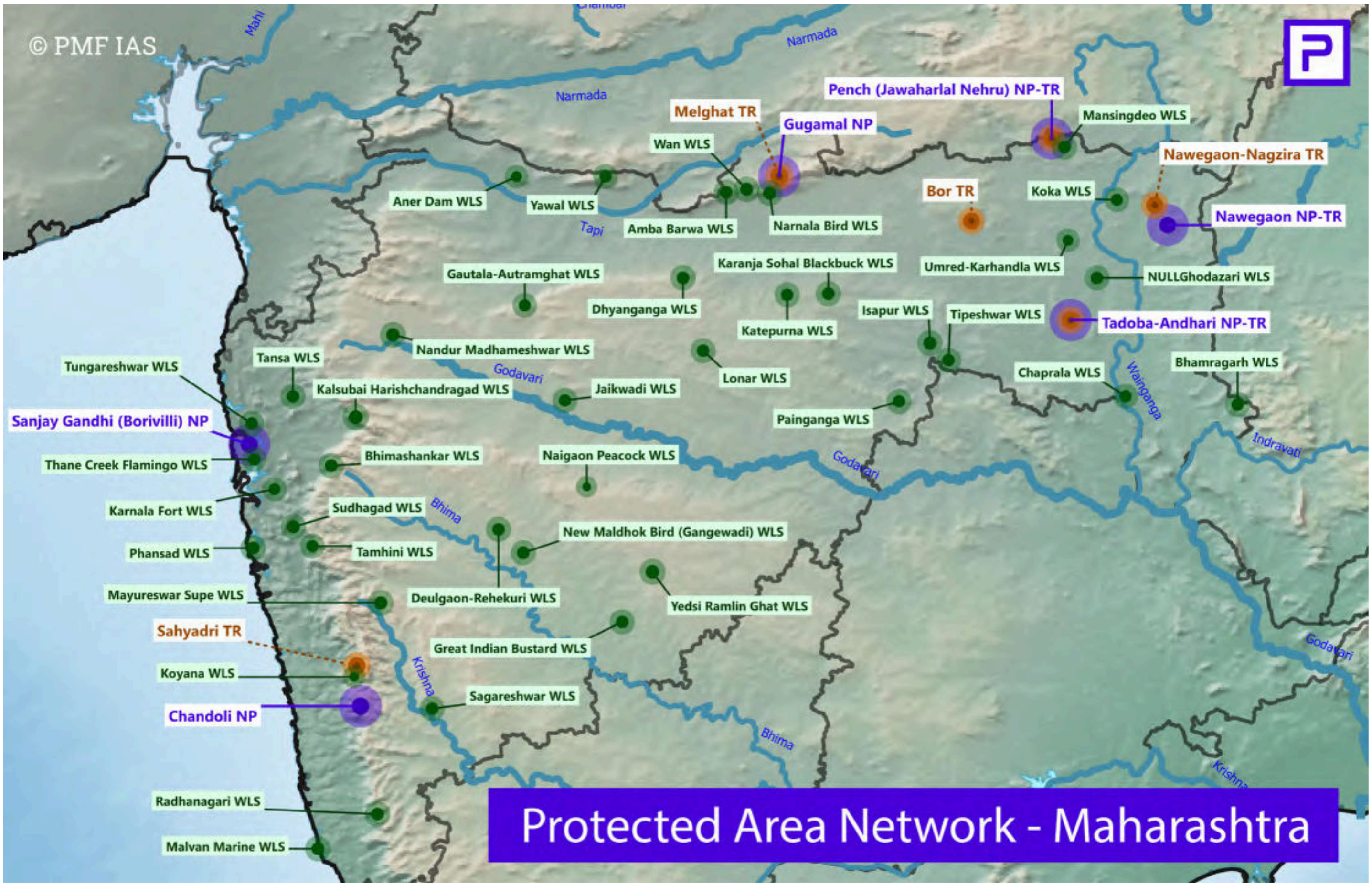
Sahyadri Tiger Reserve, Chandoli National Park, Koyna Wildlife Sanctuary

- The park stretches along the crest of the **Sahyadri Range of the Western Ghats**.
- **Sahyadri Tiger Reserve** includes **Chandoli National Park** and **Koyna Wildlife Sanctuary**.
- Koyna Wildlife Sanctuary and Chandoli National Park are about 170 km apart.
- The Koyna WLS has two reservoirs along the **Koyna River**.
- The **Shivsagar Lake** is the south reservoir **Koyna reservoir** (**Koyna Dam – 1967 Koynanagar earthquake is said to be induced by this dam**) **is the north reservoir.**
- Vegetation: moist deciduous forests.
- Major Fauna: tiger, leopard, gaur, sloth bear, giant squirrel, barking deer, sambar, mouse deer, blackbuck, etc.

Sanjay Gandhi (Borivilli) National Park

- Location: north-eastern part of **Mumbai city**.
- It is one of the major NPs existing within a metropolis limit (most visited NP in the country).
- 2400-year-old **Kanheri caves** sculpted out of a massive basalt outcrop lie within the park.
- The **Kanheri caves** served the purpose of **Buddhist centres of education**.



Tadoba Andhari Tiger Reserve, Tadoba National Park

- **Tadoba Andhari Tiger Reserve** is Maharashtra's oldest and largest national park.
- **Tadoba Lake** and **Erai Reservoir** are the major wetlands in the reserve.
- Erai reservoir offers a good habitat for **mugger (marsh crocodile – VU) crocodiles**.
- Vegetation: dry deciduous forest. Teak is the predominant tree species.

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- Major Fauna: Bengal tiger, Indian leopards, gaur, nilgai, dhole, small Indian civet, sambar, barking deer, chital, chausingha, etc.
- Threats: human habitations in the core and buffer area and forest fires.

37.3.18. Manipur

Keibul-Lamjao National Park

- It is an **integral part of Loktak Lake (Ramsar Site)**.
- The National Park is a **swamp with floating decomposed plant materials** locally called **phumdis**.
- It was declared a NP to preserve the natural refuge of **Manipur Eld's deer or thamin, brow-antlered deer or sangai or dancing deer (EN)**.
- Major Fauna: eld's deer, hog deer, large Indian civet, Asian golden cat, etc.

37.3.19. Meghalaya

Balphakram National Park

- It is located south of **Garo Hills** at an altitude of about 910 m.
- Major Fauna: barking deer, Asian golden cat, tiger, marbled cat, **wild water buffalo, red panda**, elephant, etc.

Nokrek Ridge National Park

- It forms the core area of the **Nokrek Biosphere Reserve**.
- It is located in the **West Garo Hills** district of Meghalaya.
- Major Fauna: **red panda**, Asian elephant, **stump-tailed macaque, pig-tailed macaque, hoolock gibbon**, etc.

37.3.20. Mizoram

Dampa Tiger Reserve

- It is located on the western fringes of the **Lushai Hills (Mizo Hills)** at an altitude range of 800-1,100 m.
- **No tiger was found in Buxa (WB), Dampa (Mizoram)** & **Palamau (Jharkhand)** reserves **in the 2018 tiger census**.
- It has one of the highest **clouded leopard (VU)** populations in South & South East Asia.
- Major Fauna: tiger, Indian leopard, **clouded leopard**, gaur, barking deer, hoolock gibbon, grey langur, etc.
- Threats: shifting cultivation, oil palm and teak plantations, bamboo forest and scrub replacing evergreen and semi-evergreen forests.

Murlen National Park

- It is close to the **Chin Hills of Myanmar**.
- It is to the south of **Lengteng Wildlife Sanctuary**.
- Vegetation: dense semi-evergreen and sub montane forests.
- Major Fauna: tiger, leopard, sambar, barking deer, Malayan giant squirrel, Himalayan black bear, serow, hoolock gibbon, rhesus macaque, etc.

Phawngpui Blue Mountain National Park

- It covers the entire **Phawngpui mountain** (**Blue Mountain** – 2,157 m – the highest peak in the state).
- Major Fauna: mountain goat, slow loris, tiger, leopard, leopard cat, serow, goral, etc.
- **Mrs. Hume's pheasant (NT)**, the **state bird of Mizoram,** is found here.

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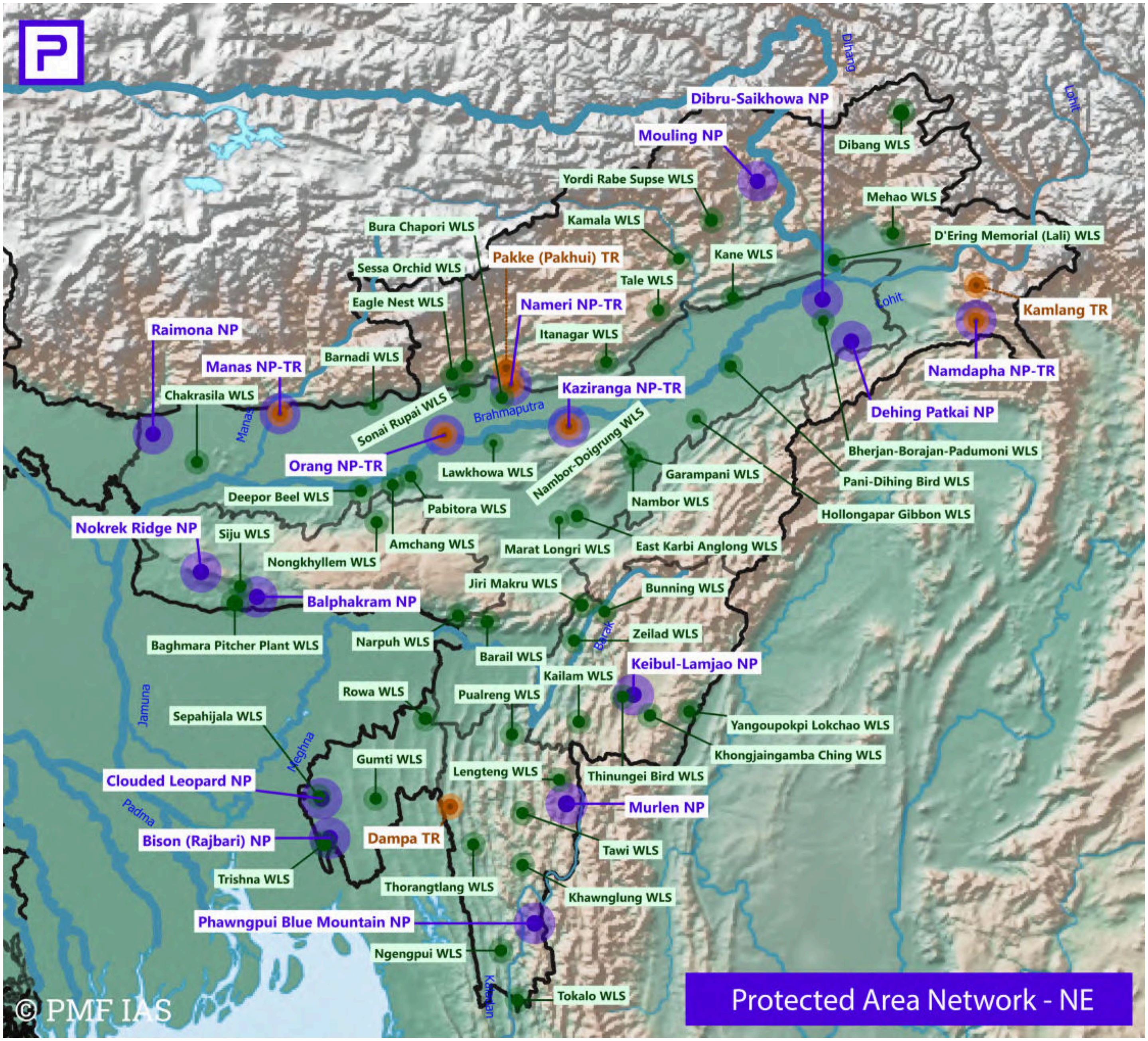
37.3.21. Nagaland

Intanki National Park

- It is located just outside the western periphery of **Barail Range**.
- Major Fauna: **hoolock gibbon, golden langur**, hornbill, etc.



37.3.22. Odisha

Bhitarkanika National Park, Wildlife Sanctuary, Ramsar Site

- **Bhitarkanika National Park** is located in northeast Kendrapara district in Odisha.
- It is the second **Ramsar site** of the state after **Chilika Lake**.
- It is surrounded by **Bhitarkanika Wildlife Sanctuary**.
- **Gahirmatha Marine Sanctuary separates the park from the Bay of Bengal**.
- The national park and wildlife sanctuary is inundated by the rivers **Brahmani, Baitarani & Dhamra**.

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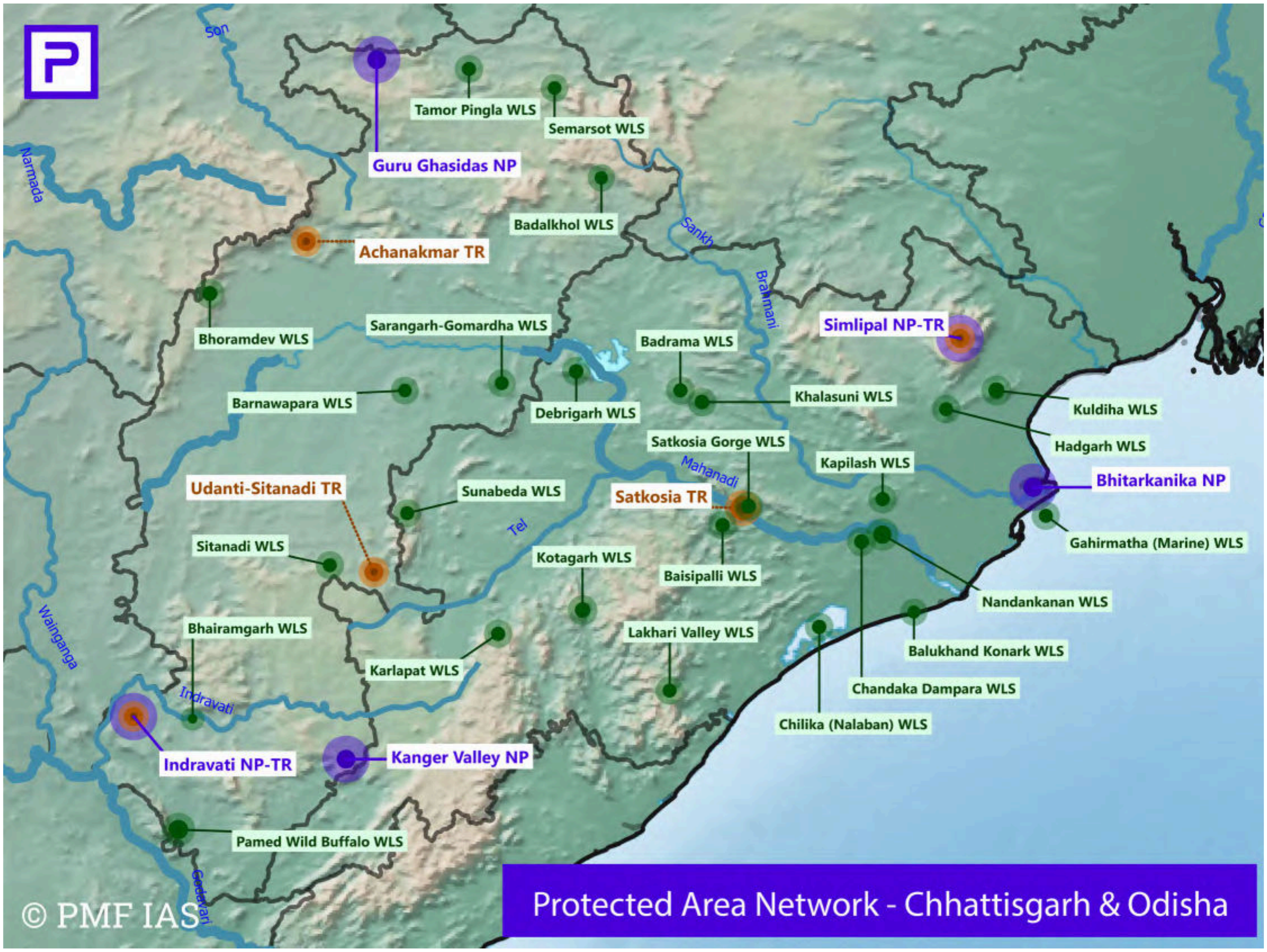
- It hosts many **mangrove species** and is the **second-largest mangrove ecosystem in India**.
- Major Fauna: **Saltwater (Estuarine) Crocodile (LC)**, Indian python, king cobra, etc.
- Major Flora: **Mangrove species**.



Gahirmatha Marine Wildlife Sanctuary

- It is the world's most important nesting beach for **Olive Ridley Sea Turtles (VU)**.
- The beach is part of **Gahirmatha Marine WLS**, which also includes the adjacent portion of the Bay of Bengal.
- It extends from **Dhamra River** mouth in the north to **Brahmani river** mouth in the south.

Chilika Lake Ramsar Site & Nalbana Bird Sanctuary

- **Chilika ephemeral (not permanent) Lake** is a **brackish water lagoon** (shallow body of water separated from a larger body of water by barrier islands or reefs).
- It is a shallow **bar-built estuary** (partially enclosed coastal area of brackish water).
- The western and southern margins of the lake are fringed by the Eastern Ghats hill range.
- It is located at the mouth of the **Daya River**, flowing into the Bay of Bengal.
- It is the **largest coastal lagoon in India** and the **largest brackish water lagoon in Asia**.
- In 1981, Chilika Lake was designated the **first Indian wetland of international importance under the Ramsar Convention**.

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- The highly productive Chilika Lagoon ecosystem, with its rich fishery resources sustains the livelihood for many fishermen who live in and near the lagoon.
- Threats: Siltation due to littoral drift and sediments from the inland river systems, shrinkage of water surface area, decrease in salinity and fishery resources, the proliferation of freshwater invasive species, etc.

Chilika Development Authority (CDA)

- In 1992, the Government of Odisha set up the Chilika Development Authority (CDA).
- The CDA was set up for the restoration and overall development of the lake.
- The governing body of the Authority is **headed by the Chief Minister of Odisha State**.

Avi Fauna

- Chilka is the **largest wintering ground for migratory birds** on the Indian sub-continent.
- Birds from as far as the **Caspian Sea, Lake Baikal, Aral Sea** and remote parts of the steppes of Asia come here.
- These birds travel great distances, possibly up to 12,000 km, to reach Chilika Lake.

Major Fauna

- The rare and threatened animal species identified are **green sea turtle (EN), dugong (VU), Irrawaddy dolphin (EN), Spoon-billed sandpiper (CR), Chilika limbless skink or Madras Spotted Skink (CR), etc.**
- The **Irrawaddy dolphin** is the flagship species of Chilika lake.
- Chilika is home to the only known population of Irrawaddy dolphins in India.

Nalbana Bird Sanctuary

- **Nalbana Bird Sanctuary** or **Nalbana Island** is the **core area of the Ramsar wetlands of Chilika Lake**.
- It was declared a bird sanctuary under the Wildlife Protection Act in 1972.
- In the heart of the park, one can see thousands of birds descending during the migratory season.
- The island disappears during monsoon season due to inundation, only to emerge again in post-monsoon.

Satkosia Tiger Reserve

- Satkosia Tiger Reserve = **Satkosia Gorge Wildlife Sanctuary** + **Baisipalli Wildlife Sanctuary**.
- It is located where the **Mahanadi River passes through a 22 km long gorge in the Eastern Ghats mountains**.
- The area is also a part of the **Mahanadi elephant reserve**.
- Vegetation: moist deciduous forests, including sal and riverine forest.
- Major Fauna: tiger, elephant, etc.

Simlipal Biosphere Reserve, Tiger Reserve, National Park

- Location: Eastern Ghats of Odisha
- It is a **UNESCO World Network of Biosphere Reserves**.
- **Mayurbhanj Elephant Reserve** = **Similipal TR + Hadgarh WLS + Kuldiha WLS**.
- Major Fauna: royal Bengal tigers, wild elephants, gaurs (Indian bison), chausingha, etc.

37.3.23. Punjab

Abohar Wildlife Sanctuary

- **Abohar WLS** is located in the Fazilka District, close to the **intersection of Haryana, Rajasthan and Punjab**.
- Unlike other wildlife sanctuaries that are located over public land, the **Abohar WLS spreads over the private land inhabited by the Bishnoi community**.
- The **blackbuck (LC) is the State Animal of Punjab** and is considered to be sacred by the Bishnois.
- The Bishnoi community has shown concern and taken up the responsibility to protect the blackbuck deer.

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- The community also protects the **blue bull,** popularly known as the **Nilghai (LC)**.

37.3.24. Rajasthan

Desert National Park

- It is situated in Jaisalmer district and Barmer district.
- Avian Major Fauna: **Great Indian bustard (CR)**.
- Major Fauna: Chinkara or Indian Gazelle, desert fox, Bengal fox, etc.

Q. With reference to India's Desert National Park, which of the following statements are correct?

1. It is spread over two districts.
2. There is no human habitation inside the park.
3. It is one of the natural habitats of the Great Indian Bustard.

Select the correct answer using the code given below;

a) 1 and 2 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Answer: Usually, no human settlements are allowed in a National Park. But there are some exceptions. c) 1 & 3 only.

Keoladeo Ghana National Park

- The park is a **freshwater swamp** and is flooded during the monsoon.
- It was previously known as **Bharatpur Bird Sanctuary**.
- It is a famous avifauna sanctuary that hosts thousands of birds, especially during the winter season.
- It is a **Ramsar Site** and **UNESCO World Heritage Site**.
- Vegetation: tropical dry deciduous forests mixed with dry grasslands and wetlands.
- It is the **only regular wintering area in India** for the **Siberian crane (CR)**.
- Avian Major Fauna: **Migratory waterfowl**, painted storks, **sarus crane (VU) (large non-migratory crane found in parts of India)**, etc.
- Major Fauna: rhesus macaque, nilgai, blackbuck, hog deer, chital deer, sambar, etc.

Mukundra Hills Tiger Reserve, National Park

- It was previously known as **Darrah Wildlife Sanctuary**.
- It is located within the Kathiawar-Gir dry deciduous forests' ecoregion.
- Like **Sita Mata Wildlife Sanctuary**, **Mukandara hills national park** was one of the places which were **considered for the reintroduction of the Asiatic lion**.
- The lions used to occur in Rajasthan but are now confined to Gir Forest National Park in Gujarat.

Ramgarh Vishdhari Tiger Reserve

- **Ramgarh Vishdhari Tiger Reserve** in Bundi district is the **fourth tiger reserve in Rajasthan**.
- It acts as a **buffer for Ranthambore National Park**.
- Ramgarh Vishdhari TR will link **Ranthambore TR** in the Northeast & **Mukundra Hills TR** on the southern side.
- The government is making efforts to strengthen the prey base by transferring **chital (spotted deer)** from **Ghana Bird Sanctuary (Karauli)** to **Mukundra Hills Tiger Reserve, Keoladeo National Park**, and **Ramgarh Vishdhari TR**.

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Ranthambhore Tiger Reserve, National Park

- It is bounded to the north by the **Banas River** and to the south by the **Chambal River**.
- The **confluence of the Banas River and the Chambal River** is just a few miles to the east of the park.
- According to experts, there is **overcrowding at the Ranthambore reserve**.
- The Rajasthan government has announced its plan to develop the **Bundi sanctuary** as a tiger reserve to provide a second habitat for tigers in the **Ranthambore Reserve**.
- Vegetation: dry deciduous forests and grasslands.
- Major Fauna: Bengal Tiger, Indian leopard, nilgai, sambar, sloth bear, **mugger crocodile**, etc.
- Threats: poaching, poisoning of tigers by villagers, habitat fragmentation, etc.

Sariska Tiger Reserve, National Park

- Vegetation: arid forests, dry deciduous forests, scrub-thorn and grasslands.
- It is a part of the **Aravalli Range** and the Kathiawar-Gir dry deciduous forests' ecoregion.
- It is **rich in mineral resources, such as copper**.
- Major Fauna: Bengal tiger, Indian leopard, **golden jackal**, chital, sambar deer, nilgai, rhesus macaque, etc.
- Threats: **marble mining**, habitat fragmentation and poaching.
- In January 2005, it was reported that there were no tigers left in Sariska.
- In July 2008, two tigers from **Ranthambhore National Park** were relocated to **Sariska Tiger Reserve**.

37.3.25. Sikkim

Khangchendzonga National Park, Biosphere Reserve

- The park gets its name from the mountain **Kangchenjunga** — the **third-highest peak in the world**.
- It is also a **Biosphere reserve**.
- It is a **UNESCO World Heritage Site** and the first "Mixed Heritage" site of India.
- It is also included in the **UNESCO Man and the Biosphere Programme**.
- Vegetation: temperate broadleaf and mixed forests consisting of oaks, fir, birch, maple, willow.
- Major Fauna: **musk deer, snow leopard, Himalayan tahr**, wild dog, sloth bear, Himalayan black bear, **red panda, Tibetan wild ass, Himalayan blue sheep, serow, goral, takin**, etc.

37.3.26. Tamil Nadu

Annamalai (Indira Gandhi) Tiger Reserve, National Park, Wildlife Sanctuary

- Located in the **Anaimalai Hills** of Coimbatore District.
- Vegetation: vertical zonation of vegetation ranges from wet evergreen forest to montane shola grassland.
- Major Fauna: Bengal tiger, Indian elephant, Indian leopard, Nilgiri tahr, **lion-tailed macaque**, gaur, Nilgiri langur, rusty-spotted cat, Indian giant squirrel, bonnet macaque, etc.
- Threats: tea and coffee plantations and tourism.

Guindy National Park

- It is located in **Chennai city**.
- It is an extension of the grounds surrounding Raj Bhavan.
- **Guindy Snake Park** and **IIT Madras** are located at the periphery of Guindy National Park.
- The **Madras Crocodile Bank Trust** is only 30km away from Guindy National Park.
- Vegetation: tropical dry evergreen forest, dry evergreen scrub and thorn forest.

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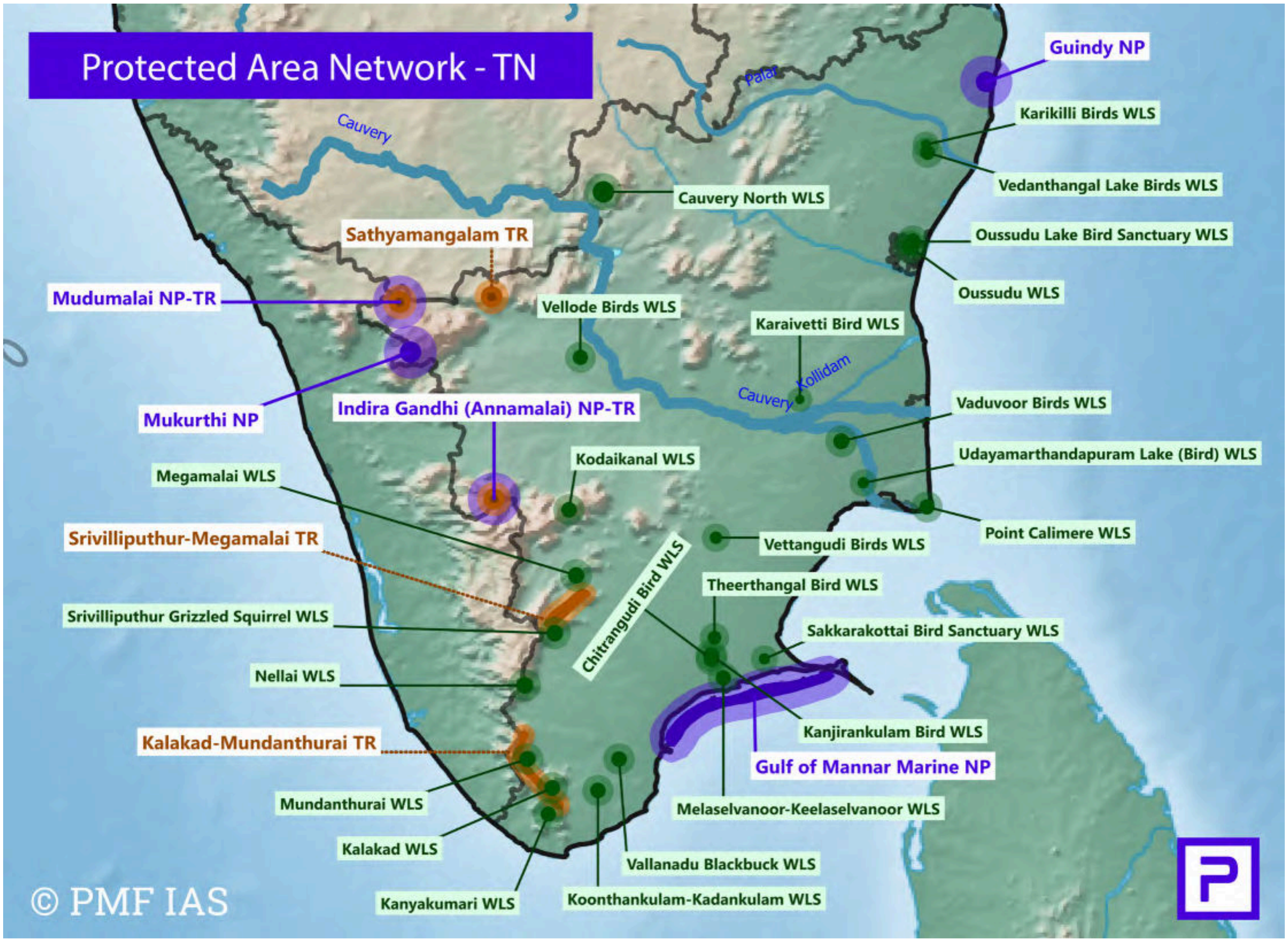
- Major Fauna: blackbucks, spotted deer (chital), jackals, etc.
- The **blackbuck** is considered the **flagship species of the park**.

Madras Crocodile Bank Trust

- It is a reptile zoo and research station on the outskirts of Chennai.
- It was established to save Indian EN species of crocodile — the **marsh or mugger crocodile (VU), the saltwater crocodile (LC)**, and the **gharial (CR)**.
- The place offers a secure nesting beach for **olive ridley sea turtles**.
- It has one of the world's largest collections of crocodiles and alligators.

Gulf of Mannar Marine National Park

- It consists of 21 small islands (islets) and adjacent **coral reefs in the Gulf of Mannar**.
- It is the core area of the **Gulf of Mannar Biosphere Reserve**.
- It includes marine components such as **coral reefs, seaweed, seagrasses, salt marshes** and **mangroves**.
- Major Fauna: Dugong (Sea Cow), Green turtles, Olive Ridley turtles, etc.
- **Dugong (VU)**, a marine mammal, is the **flagship mammal of the park**.
- Threats: tourism, coral mining, illegal fishing, illegal mechanized fishing, etc.



Kalakad-Mundanthurai Tiger Reserve

- It forms part of the inter-state **Agasthyamalai Biosphere Reserve**.
- **Agasthiyamalai Hill Range** is the core zone of the reserve.

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- Major Fauna: tiger, leopard, elephant, gaur, sambar, chital, Nilgiri tahr, mouse deer, lion-tailed macaque, bonnet macaque, Nilgiri langur, crocodile, etc.

Mudumalai Tiger Reserve, National Park, Wildlife Sanctuary

- It lies on the north-western side of the **Nilgiri Hills (Blue Mountains)**, in Nilgiri District.
- It shares its boundaries with the states of Karnataka and Kerala.
- Vegetation: tropical moist deciduous, tropical dry deciduous forest, tropical dry thorn forests are in the east.
- Major Fauna: **Indian elephant, Bengal tiger, gaur**, Indian leopard, golden jackal, grey langur (Hanuman langur), bonnet macaque, sloth bear, sambar deer, Indian muntjac, Indian giant squirrel, red giant flying squirrel, etc.
- Avian Major Fauna**: Indian white-rumped vulture (CR)** and **India Vulture (CR)**.
- Threats: Tourism and invasive species such as Lantana.

Mukurthi National Park

- Location: Nilgiri Biosphere Reserve; northwest corner of Tamil Nadu; west of Ooty hill station.
- The park was created to protect its **keystone species**, the **Nilgiri tahr (EN)**.
- Vegetation: montane grasslands and shrublands interspersed with sholas in high altitude areas.
- Major Fauna: Nilgiri tahr, Indian elephant, Bengal tiger, Nilgiri marten, Nilgiri langur.
- The park is a part of Nilgiri Biosphere Reserve.
- Threats: Invasive species like wattle species, eucalyptus, etc.

Sathyamangalam Tiger Reserve, Wildlife Sanctuary

- Location: the **Eastern Ghats** in the Erode District.
- Sathyamangalam Tiger Reserve = **Sathyamangalam + Hasanur Forest Divisions**.
- It is a **wildlife corridor** in the **Nilgiris Biosphere Reserve** between the Western Ghats and the rest of the Eastern Ghats and a genetic link between **BR Hills WLS, Mudumalai NP** and **Bandipur NP**.
- Vegetation: dry deciduous forest and grasslands.
- Major Fauna: Bengal tiger, elephant, gaur, leopard, spotted deer, blackbuck, sambar deer, barking deer, etc.
- Threats: rampant poaching of tigers and elephants, high degree of human interference and forest fires.

Srivilliputhur-Megamalai Tiger Reserve

- **Srivilliputhur Megamalai Tiger Reserve** is the **fifth tiger reserve in Tamil Nadu**.
- It was created by combining **Srivilliputhur Grizzled Giant Squirrel Sanctuary** and **Megamalai WLS**.
- The biggest beneficiary is the dying **Vaigai River**. The formation of TRs have kept the rivers perennial in the region.
- The **Vaigai** is 258 kilometres long empties into the **Palk Strait near the Pamban Bridge** in Ramanathapuram district.
- Srivilliputhur-Megamalai TR provides crucial breeding and home ranges for tigers straying out of neighbouring **Periyar Tiger Reserve** and the **Anamalai Tiger Reserve**.

37.3.27. Telangana

Amrabad Tiger Reserve, Wildlife Sanctuary

- Earlier, it was part of **Nagarjunasagar-Srisailam Tiger reserve,** but post-bifurcation, the northern part of the reserve is vested with Telangana state and renamed as **Amrabad Tiger Reserve**.
- It is India's **second-largest tiger reserve, next only to Nagarjunasagar Srisailam Tiger Reserve**.
- Major Fauna: **endemic yellow-throated bulbul (VU)** and the **star tortoise (VU)**; mugger crocodile, tiger, leopard, nilgai, sambar, chausingha, sloth bear, etc.

Chenchu tribe

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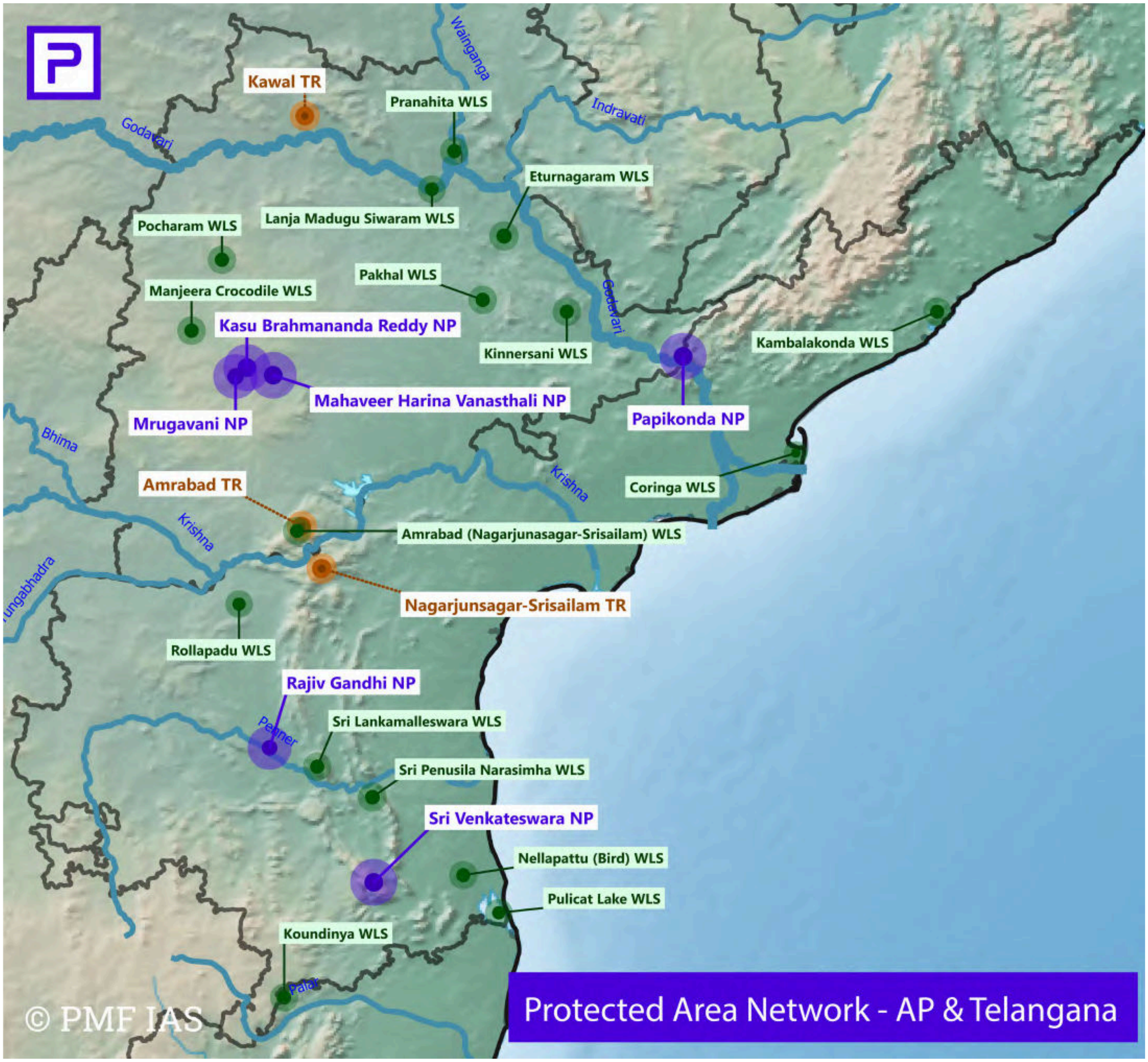

- **Chenchus** are a **hunter-gatherer community**.
- They are a designated Scheduled Tribe in Andhra Pradesh, Telangana, Karnataka and Odisha.
- They were in the news recently due to the Telangana government's plan to start **uranium mining in Amrabad**.
- The uranium exploration and mining will leech dangerous chemicals into the Krishna River.
- It will also take away the livelihoods of the Chenchus.

Kasu Brahmananda Reddy National Park

- It is a jungle amidst the concrete jungles of Jubilee Hills and Banjara Hills in **Hyderabad City**.

Kawal Tiger Reserve, Wildlife Sanctuary

- It is located in the northern districts of Telangana.
- The **river Godavari** flows along the southern boundary of the reserve.
- Vegetation: dry deciduous teak forests mixed with bamboo.
- Major Fauna: tiger, leopard, gaur, cheetal, sambar, nilgai, barking deer, chausingha, sloth bear, etc.

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- Threats: growing human encroachment, rampant poaching, illegal wood felling and habitat loss.

Mahaveer Harina Vanasthali National Park

- It is a deer park on the **outskirts of Hyderabad**.
- The park was named after Mahavir, a Jain saint.

Mrugavani National Park

- It is located on the **outskirts of Hyderabad**.
- Major Fauna: spotted deer, wild boars, foxes, etc.

37.3.28. Tripura

Bison (Rajbari) National Park

- **Rajbari National Park** is a national park in the **Trishna Wildlife Sanctuary**.
- Trishna WLS was established to restore the natural living habitat of the **India Bison (Indian Gaur – VU)**.
- The **Gumti River** originating from the **Gumti Wildlife Sanctuary (in Tripura),** separates the **Sipahijola WLS (Clouded Leopard National Park)** from **Trishna WLS (Bison National Park)**.
- **Rudrasagar Lake (Ramsar Site)** is located between the **Sipahijola WLS** and the **Trishna WLS.**
- Vegetation: tropical semi-evergreen forest, savannah woodland and bamboo forests.
- Major Fauna: **Indian Gaur**, deer, Golden langurs, etc.

Clouded Leopard National Park

- **Clouded Leopard National Park** is a part of the **Sipahijola Wildlife Sanctuary**.
- Sipahijola WLS is a woodland with an artificial lake with natural botanical and zoological gardens.
- Sipahijola WLS is famous for **clouded leopard (VU)** enclosures.

37.3.29. Uttar Pradesh

Amangarh Tiger Reserve (buffer of Jim Corbett TR)

- It is in Amangarh in Bijnor district.
- **Amangarh Tiger reserve** forms an extension of and buffer to **Jim Corbett National Park**.
- After the state of Uttarakhand was carved out of Uttar Pradesh, **Jim Corbett went to Uttarakhand** and **Amangarh remained in Uttar Pradesh**.

Dudhwa Tiger Reserve, National Park

- Location: Terai belt of marshy grasslands (**Indo-Nepal border**) of northern Uttar Pradesh.
- **Dudhwa TR** = **Dudhwa NP** + **Kishanpur WLS** and the **Katarniaghat WLS**.
- The **Sharda River** (also called **Kali River** and Mahakali River) separates Dudhwa NP from Kishanpur WLS.
- The **Ghaghara River** separates Dudhwa NP from Katarniaghat WLS.
- **Indian rhinoceros (VU)** was reintroduced into Dudhwa from **Pobitora Sanctuary** in **Assam**.
- Major Fauna: swamp deer (barasingha), sambar deer, barking deer, spotted deer, hog deer, tiger, **rhinoceros**, elephants, cheetal, etc.
- June 2019: The **black-crested Bulbul (LC)** was spotted after several years in Dudhwa.

Pilibhit Tiger Reserve

- It lies along the **India-Nepal border** in the foothills of the Himalayas and the plains of the 'terai'.
- The **Sharda Sagar Dam** is on the eastern boundary of the reserve.

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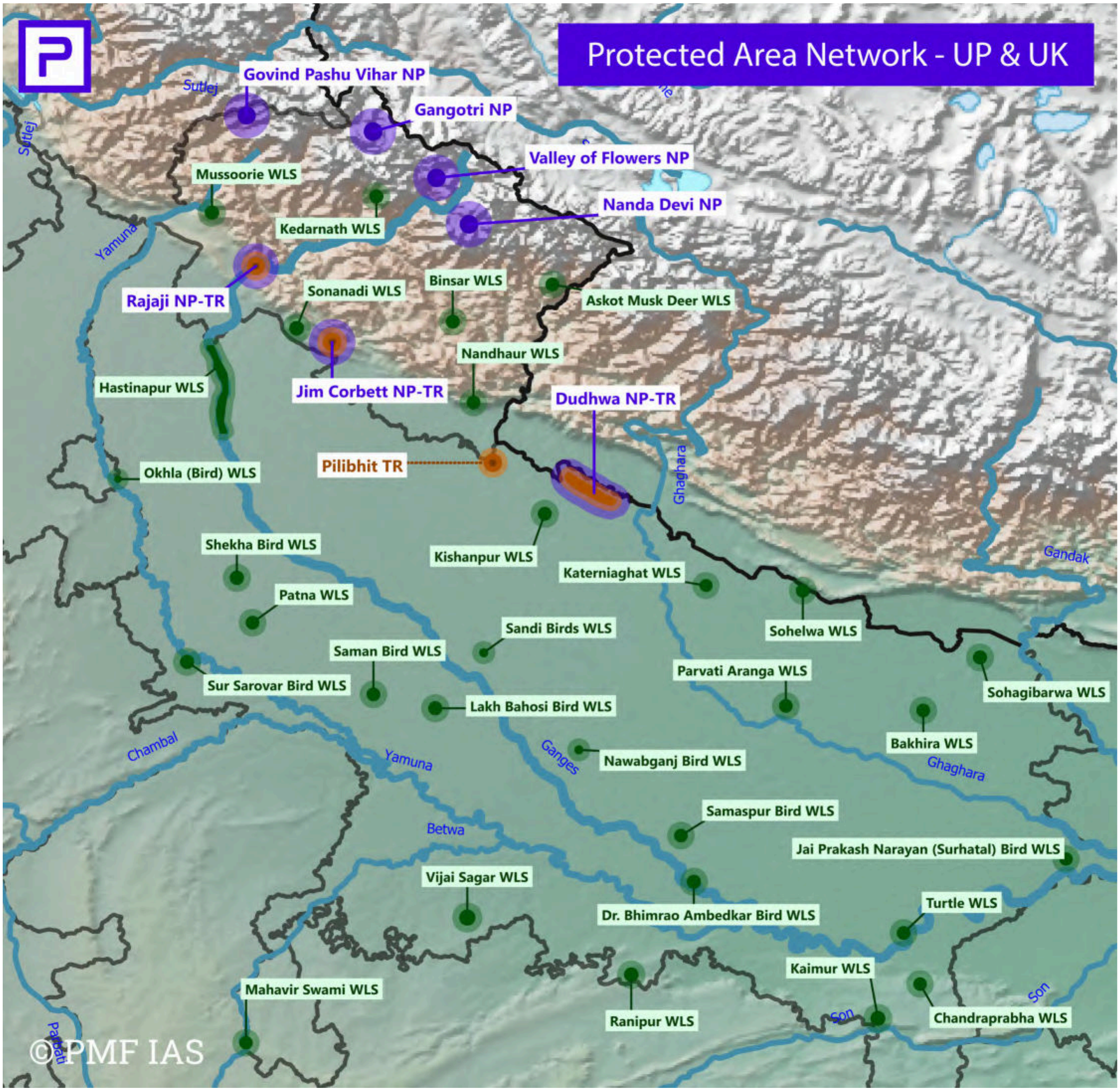
- **River Sharda** (a tributary of **River Ghaghara**) forms the north-eastern boundary of the reserve.
- Vegetation: sal forests, tall grasslands and swamps characterized by periodic flooding.
- Major Fauna: Bengal tiger, leopard, swamp deer, spotted deer, hog deer, barking deer, blackbuck, sambar, sloth bear, rhesus macaque, common langur, porcupine, small Indian civet, **gharial**, etc.



37.3.30. Uttarakhand

Gangotri National Park

- The Gangotri National Park is located in the upper catchment of **Bhagirathi river**.
- The Park area forms a continuity between **Govind National Park** and **Kedarnath Wildlife Sanctuary**.
- The **Gaumukh glacier**, the origin of the river Ganges is located inside the park.

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- Habitat: coniferous forests, alpine meadows and glaciers.
- Vegetation: pine, deodar, fir, spruce, oak and rhododendrons.
- Major Fauna: **snow leopard, Asian black bear, brown bear, musk deer, blue sheep, Himalayan tahr**, etc.

Govind Pashu Vihar National Park and Wildlife Sanctuary

- It is named after a prominent Indian freedom fighter and politician, **Govind Ballabh Pant**.
- The park lies in the higher reaches of the **Garhwal Himalayas**.
- The **Snow Leopard Project** started by the Government of India is being managed at this sanctuary.
- Vegetation: western Himalayan broadleaf forests at lowest elevations, transitioning to conifer forests and alpine shrub and meadows at its highest elevations.
- Trees present in the lower parts of the sanctuary include chir, pine, deodar cedar and oak.
- At altitudes over about 2,600 m, common species include conifers such as blue pine, silver fir, spruce, yew, and deciduous species such as oak, maple, walnut, horse chestnut, hazel and rhododendron.
- Major Fauna: **Snow Leopard (VU)**, Asian black bear, brown bear, common leopard, musk deer, Himalayan tahr, golden eagle, steppe eagle, black eagle, bearded vulture, etc.

Jim Corbett National Park

- Jim Corbett National Park is the **oldest National Park in India**.
- It was established in 1936 to protect the **Bengal tiger**.
- It was named after Jim Corbett, a well-known hunter and naturalist.
- The park was the **first to come under the Project Tiger initiative**.
- The core area forms the Jim Corbett NP, while the buffer contains **Sonanadi Wildlife Sanctuary**.
- The park comprises marshy depressions, grasslands and a large lake (**Ramganga Reservoir**).
- Vegetation: dense, moist deciduous forest mainly consists of sal, peepal, and mango trees.
- Major Fauna: **Bengal tigers, elephants**, leopards, barking deer, sambar deer, hog deer, chital, sloth and Himalayan black bears, Indian grey mongoose, Himalayan goral, Indian pangolins, rhesus macaques, etc.
- Local crocodiles and **gharials** were saved from extinction by **captive breeding** programs that subsequently released crocodiles into the **Ramganga river**.
- Threats: exotic weeds Lantana, Parthenium and Cassia, poaching.
- Corbett National Park is one of the thirteen protected areas covered by the Worldwide Fund For Nature under their **Terai Arc Landscape Program**.

Terai Arc Landscape Program

- The Terai Arc Landscape (TAL) is an 810km stretch between the river **Yamuna** in the west and the river **Bhagmati** in the east, comprising the Shivalik hills, the adjoining **bhabhar areas** and the Terai flood plains
- TAL aims to protect three terrestrial flagship species, **the tiger, the Asian elephant** and the **great one-horned rhinoceros**, by restoring forest corridors by linking 13 protected areas to enable wildlife migration.
- TAL is spread across the states of Uttarakhand, Uttar Pradesh and Bihar, and the low-lying hills of Nepal.
- TAL consists of **Corbett Tiger Reserve, Rajaji National Park, Dudhwa Tiger Reserve, Valmiki Tiger Reserve** and Nepal's Bardia Wildlife Sanctuary, Chitwan NP, and Sukhla Phanta Wildlife Sanctuary.
- In total, the landscape has 13 Protected Areas, **nine in India** and four in Nepal.

Nanda Devi National Park

- The **Nanda Devi Biosphere Reserve** is situated around the peak of **Nanda Devi (7816 m)**.
- The entire park lies at an elevation of more than 3,500 m above mean sea level.

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- The National Park is a **UNESCO World Heritage Site**.
- Major Fauna: Himalayan musk deer, mainland serow, Himalayan tahr, **Himalayan black bear**.

Rajaji Tiger Reserve, National Park

- Location: **Shivalik ranges and the Indo-Gangetic plains** in Uttarakhand.
- The **Ganga and Song rivers** flow through the park.
- The NP has been named after **C. Rajagopalachari** (second Governor-General of independent India).
- The park is at the **north-western limit of distribution for both elephants and tigers in India**.
- Major Fauna: elephants, Bengal tiger, sloth bear, black bear, Indian langur, Indian porcupine, etc.

Valley of Flowers National Park

- The Valley of Flowers is a **high-altitude Himalayan valley**.
- It is known for its **meadows of endemic alpine flowers**.
- Both the **Valley of Flowers National Park** and the **Nanda Devi National Park** are encompassed in the **Nanda Devi Biosphere Reserve**.
- Vegetation: alpine vegetation.
- Major Fauna: the park is home to EN animals, including the **Asiatic black bear, snow leopard, musk deer, brown bear**, red fox, and **blue sheep**.

Q. Which one of the following national parks lies completely in the Temperate alpine zone?

a) Manas national park
b) Namdapha national park
c) Neora valley national park
d) Valley of flower national park

Answer: d)

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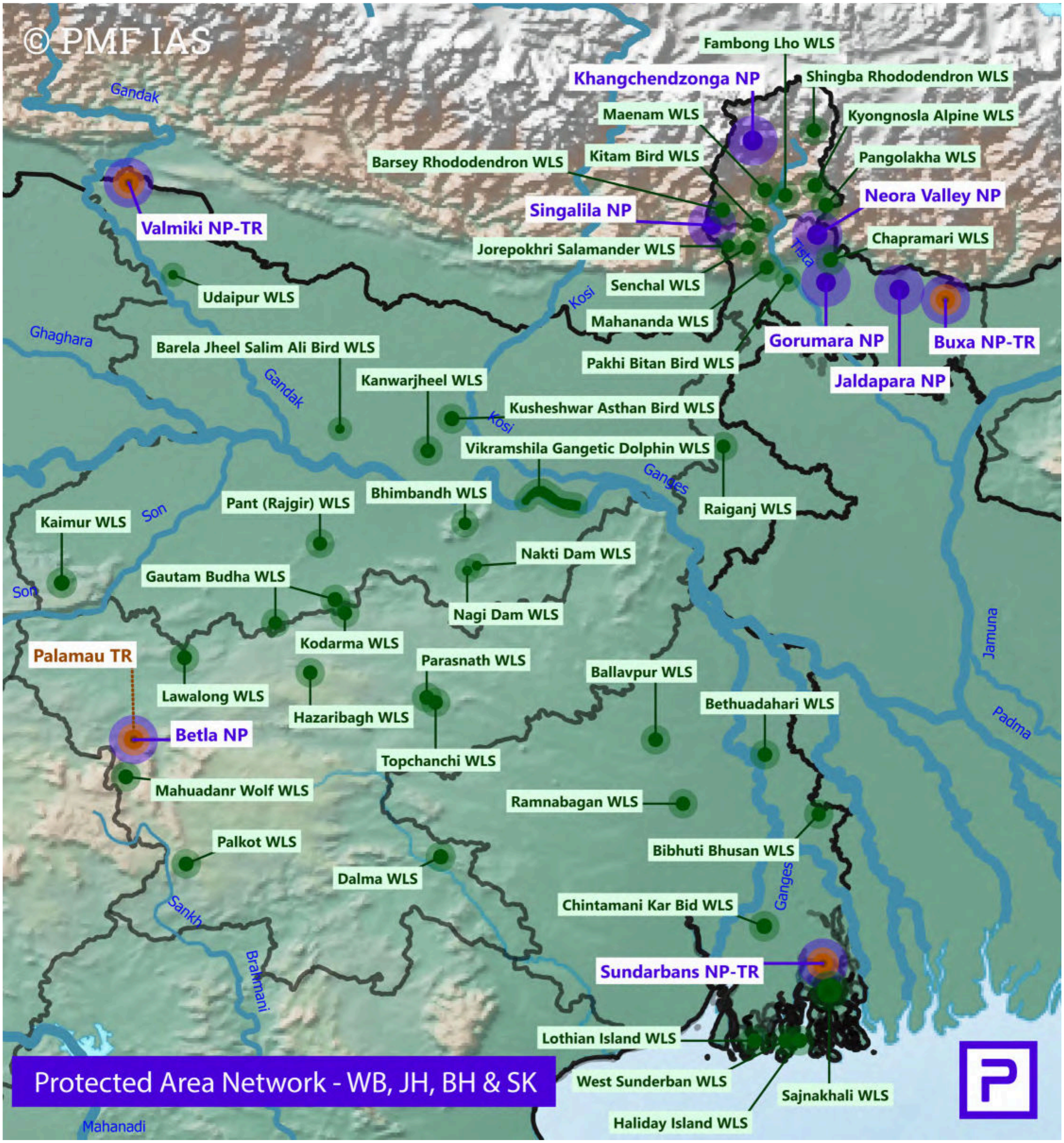
37.3.31. West Bengal



Buxa Tiger Reserve, National Park

- In altitude, it ranges from 60 m in the Gangetic Plains to 1,750 m bordering the Himalayas in the north.
- Major Fauna: Bengal tiger**, Asian elephant**, gaur, sambar deer, clouded leopard, Indian leopard, etc.
- Threats: Flooding, poaching of elephants.

Gorumara National Park

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- Gorumara is located in the Eastern Himalayas' submontane Terai belt.
- The park is primarily known for its population of **Indian rhinoceros**.
- The region has **rolling forests and riverine grasslands** and is known as the **Dooars** in West Bengal.
- The major river of the park is the **Jaldhaka River**, a **tributary of the Brahmaputra River system**.
- Typical Major Flora includes Sal forests with common teak.
- Major Fauna: Indian rhinoceros, gaur, Asian elephant, sloth bear, chital, sambar deer, barking deer, hog deer, etc.

Jaldapara National Park

- It is on the banks of the **Torsa River**.
- It has the largest population of the **Indian one-horned rhinoceros** after **Kaziranga NP in Assam**.
- The nearby Chilapata Forests is an elephant corridor between Jaldapara and the Buxa Tiger Reserve.
- Nearby is the **Gorumara National Park**, known for its population of Indian rhinoceros.
- Vegetation: the forest is mainly savannah covered with tall elephant grasses.
- Major Fauna: Indian one-horned rhinoceros, Indian leopard, Indian elephants, sambar, barking deer, spotted deer, hog deer, wild boars, and gaur.

Neora Valley National Park

- Vegetation: Himalayan broadleaf forests.
- Trees: rhododendron, bamboo, oak, ferns, sal, etc.
- Major Fauna: Indian leopard, black bear, sloth bear, golden cat, barking deer, sambar, Himalayan flying squirrel and thar. The most exotic of all is **Red Panda (EN).**

Singalila National Park

- It is located on the **Singalila Ridge** in the Darjeeling district.
- Vegetation (vertical zonation of vegetation): coniferous forests, temperate broadleaf and mixed forests.
- Major Fauna: **red panda**, leopard cat, barking deer, yellow-throated marten, pangolin, Himalayan black bear, leopard, clouded leopard, takin, etc.

Sunderban Tiger Reserve, National Park

- It is also a **biosphere reserve, Ramsar Site** and a **UNESCO World Heritage Site**.

- Vegetation: **mangrove forests** (Sundarbans has achieved its name from the Sundari mangrove tree).
- The eco-geography of this area is totally dependent on the **tidal effect**.
- The tidal action deposits silts back on the channels, raising the bed and forming new islands and creeks.

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- Major Fauna: **Royal Bengal Tiger**, **saltwater crocodile**, river terrapin, olive ridley turtle, **Ganges River dolphin**, hawksbill turtle, mangrove horseshoe crab, etc.

37.4. Wildlife Sanctuaries of India

List of Wildlife Sanctuaries (Dec 2020)			
S.No.	**State**	**Protected Area**	**Area (km²)**
1	**Andaman & Nicobar Islands (96)**	1. Arial Island WLS	0.05
2		2. Bamboo Island WLS	0.05
3		**3. Barren Island WLS**	8
4		4. Battimalv Island WLS	2.2
5		5. Belle Island WLS	0.08
6		6. Benett Island WLS	3.5
7		7. Bingham Island WLS	0.08
8		8. Blister Island WLS	0.26
9		9. Bluff Island WLS	1.1
10		10. Bondoville Island WLS	2.6
11		11. Brush Island WLS	0.23
12		12. Buchanan Island WLS	9
13		13. Chanel Island WLS	0.13
14		14. Cinque Islands WLS	10
15		15. Clyde Island WLS	0.5
16		16. Cone Island WLS	0.7
17		17. Curlew (B.P.) Island WLS	0.16
18		18. Curlew Island WLS	0.03
19		19. Cuthbert Bay WLS	6
20		20. Defence Island WLS	10
21		21. Dot Island WLS	0.13
22		22. Dottrell Island WLS	0.13
23		23. Duncan Island WLS	0.7
24		24. East Island WLS	6
25		25. East of Inglis Island WLS	3.6
26		26. Egg Island WLS	0.05
27		27. Elat Island WLS	9
28		28. Entrance Island WLS	1.0
29		29. Gander Island WLS	0.05
30		30. Galathea Bay WLS	11
31		31. Girjan Island WLS	0.16
32		32. Goose Island WLS	0.01
33		33. Hump Island WLS	0.5
34		34. Interview Island WLS	134
35		35. James Island WLS	2.1
36		36. Jungle Island WLS	0.5

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37		37. Kwangtung Island WLS	0.6
38		38. Kyd Island WLS	8
39		39. Landfall Island WLS	29
40		40. Latouche Island WLS	1.0
41		41. Lohabarrack (Saltwater Crocodile) WLS	22
42		42. Mangrove Island WLS	0.4
43		43. Mask Island WLS	0.8
44		44. Mayo Island WLS	0.10
45		45. Megapode Island WLS	0.12
46		46. Montogemery Island WLS	0.21
47		**47. Narcondam Island WLS**	7
48		48. North Brother Island WLS	0.8
49		49. North Island WLS	0.5
50		50. North Reef Island WLS	3.5
51		51. Oliver Island WLS	0.16
52		52. Orchid Island WLS	0.10
53		53. Ox Island WLS	0.13
54		54. Oyster Island-I WLS	0.08
55		55. Oyster Island-II WLS	0.21
56		56. Paget Island WLS	7
57		57. Parkinson Island WLS	0.34
58		58. Passage Island WLS	0.6
59		59. Patric Island WLS	0.13
60		60. Peacock Island WLS	0.6
61		61. Pitman Island WLS	1.4
62		62. Point Island WLS	3.1
63		63. Potanma Islands WLS	0.16
64		64. Ranger Island WLS	4.3
65		65. Reef Island WLS	1.7
66		66. Roper Island WLS	1.5
67		67. Ross Island WLS	1.0
68		68. Rowe Island WLS	0.01
69		69. Sandy Island WLS	1.6
70		70. Sea Serpent Island WLS	0.8
71		71. Shark Island WLS	0.6
72		72. Shearme Island WLS	8
73		73. Sir Hugh Rose Island WLS	1.1
74		74. Sisters Island WLS	0.36
75		75. Snake Island-I WLS	0.7
76		76. Snake Island-II WLS	0.03
77		77. South Brother Island WLS	1.2

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78		78. South Reef Island WLS	1.2
79		79. South Sentinel Island WLS	1.6
80		80. Spike Island-I WLS	0.4
81		81. Spike Island-II WLS	12
82		82. Stoat Island WLS	0.4
83		83. Surat Island WLS	0.31
84		84. Swamp Island WLS	4.1
85		85. Table (Delgarno) Island WLS	2.3
86		86. Table (Excelsior) Island WLS	1.7
87		87. Talabaicha Island WLS	3.2
88		88. Temple Island WLS	1.0
89		89. Tillongchang Island WLS	17
90		90. Tree Island WLS	0.03
91		91. Trilby Island WLS	1.0
92		92. Tuft Island WLS	0.29
93		93. Turtle Islands WLS	0.39
94		94. West Island WLS	6
95		95. Wharf Island WLS	0.11
96		96. White Cliff Island WLS	0.5
97	Andhra Pradesh (13)	**1. Coringa WLS**	236
98		**2. Gundla Brahmeswaram WLS**	1,194
99		**3. Kambalakonda WLS**	71
100		**4. Koundinya WLS**	358
101		**5. Kolleru WLS**	309
102		**6. Krishna WLS**	195
103		**7. Nagarjuna Sagar-Srisailam WLS**	1,402
104		8. Nellapattu WLS	4.6
105		**9. Pulicat Lake WLS**	500
106		**10. Rollapadu WLS**	6
107		**11. Sri Lankamalleswara WLS**	464
108		12. Sri Penusila Narasimha WLS	1,031
109		13. Sri Venkateswara WLS	172
110	Arunachal Pradesh (13)	1. D'Ering Memorial (Lali) WLS	190
111		**2. Dibang WLS**	4,149
112		**3. Eagle Nest WLS**	217
113		**4. Itanagar WLS**	140
114		5. Kamala WLS	77
115		**6. Kamlang WLS**	783
116		7. Kane WLS	31
117		8. Mahao WLS	282
118		**9. Pakke (Pakhui) WLS**	862

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119		10. Ringba-Roba WLS	49
120		**11. Sessa Orchid WLS**	100
121		12. Tale WLS	337
122		13. Yordi Rabe Supse WLS	397
123	Assam (18)	**1. Amchang WLS**	79
124		**2. Barail WLS**	326
125		**3. Barnadi WLS**	26
126		4. Bherjan-Borajan-Padumoni WLS	7
127		5. Burachapari WLS	44
128		**6. Chakrasila WLS**	46
129		**7. Deepor Beel WLS**	4.1
130		**8. Dihing Patkai WLS**	111
131		**9. East Karbi Anglong WLS**	222
132		**10. Garampani WLS**	6
133		**11. Hollongapar Gibbon WLS**	21
134		**12. Lawkhowa WLS**	70
135		**13. Marat Longri WLS**	451
136		**14. Nambor WLS**	37
137		15. Nambor-Doigrung WLS	97
138		**16. Pabitora WLS**	39
139		17. Pani-Dihing Bird WLS	34
140		**18. Sonai Rupai WLS**	220
141	Bihar (12)	1. Barela Jheel Salim Ali Bird WLS	2.0
142		2. Bhimbandh WLS	682
143		**3. Gautam Budha WLS**	138
144		**4. Kaimur WLS**	1,342
145		**5. Kanwarjheel WLS**	63
146		6. Kusheshwar Asthan Bird WLS	29
147		7. Nagi Dam WLS	1.9
148		8. Nakti Dam WLS	3.3
149		9. Pant (Rajgir) WLS	36
150		10. Udaipur WLS	9
151		**11. Valmiki WLS**	545
152		**12. Vikramshila Gangetic Dolphin WLS**	50
153	Chandigarh (2)	1. City Bird WLS	0.03
154		2. Sukhna Lake WLS	26
155	Chhattisgarh (11)	**1. Achanakmar WLS**	552
156		**2. Badalkhol WLS**	104
157		3. Barnawapara WLS	245
158		**4. Bhairamgarh WLS**	139
159		**5. Bhoramdev WLS**	351

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160		6. Sarangarh-Gomardha WLS	278
161		**7. Pamed Wild Buffalo WLS**	262
162		8. Semarsot WLS	430
163		9. Sitanadi WLS	553
164		10. Tamor Pingla WLS	609
165		**11. Udanti Wild Buffalo WLS**	237
166	Dadra & Nagar Haveli	Dadra & Nagar Haveli WLS	92
167	Daman & Diu	Fudam WLS	2.2
168	Delhi	Asola Bhati (Indira Priyadarshini) WLS	28
169	Goa (6)	1. Bhagwan Mahavir WLS	133
170		2. Bondla WLS	8
171		3. Cotigaon WLS	86
172		**4. Dr. Salim Ali Bird (Chorao) WLS**	1.8
173		**5. Madei WLS**	208
174		6. Netravali WLS	211
175	Gujarat (23)	1. Balaram Ambaji WLS	542
176		2. Barda WLS	192
177		**3. Gaga (Great Indian Bustard) WLS**	3.3
178		**4. Gir WLS**	1,153
179		**5. Girnar WLS**	179
180		6. Hingolgadh WLS	7
181		7. Jambughoda WLS	130
182		8. Jessore Sloth Bear WLS	181
183		**9. Kachchh (Lala) Great Indian Bustard WLS**	2.0
184		**10. Kachchh Desert WLS**	7,506
185		11. Khijadiya Bird WLS	6
186		**12. Marine (Gulf of Kachchh) WLS**	295
187		13. Mitiyala WLS	18
188		**14. Nal Sarovar Bird WLS**	121
189		**15. Narayan Sarovar Chinkara WLS**	443
190		16. Paniya WLS	40
191		**17. Porbandar Bird WLS**	0.09
192		**18. Purna WLS**	161
193		19. Rampara Vidi WLS	15
194		20. Ratanmahal Sloth Bear WLS	56
195		21. Shoolpaneswar (Dhumkhal) WLS	608
196		22. Thol Lake WLS	7
197		**23. Wild Ass WLS**	4,954
198	Haryana (8)	1. Abubshehar WLS	115
199		2. Bhindawas Lake WLS	4.1
200		3. Bir Shikargarh WLS	8
201		4. Chhilchhila Lake WLS	0.29

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202		**5. Kalesar WLS**	54
203		6. Khaparwas WLS	0.8
204		7. Morni Hills (Khol-Hi-Raitan) WLS	49
205		8. Nahar WLS	2.1
206	Himachal Pradesh (28)	1. Bandli WLS	32
207		2. Chail WLS	16
208		**3. Chandratal WLS**	39
209		4. Churdhar WLS	56
210		**5. Daranghati WLS**	172
211		**6. Dhauladhar WLS**	983
212		7. Gamgul Siyabehi WLS	108
213		8. Kais WLS	13
214		9. Kalatop-Khajjiar WLS	17
215		10. Kanawar WLS	107
216		11. Khokhan WLS	15
217		12. Kibber WLS	2,220
218		13. Kugti WLS	405
219		14. Lippa Asrang WLS	31
220		15. Majathal WLS	31
221		**16. Manali WLS**	29
222		17. Nargu WLS	132
223		**18. Pong Dam Lake WLS**	208
224		19. Rakchham Chitkul (Sangla Valley) WLS	304
225		**20. Renuka WLS**	4.0
226		21. Rupi Bhaba WLS	503
227		22. Sainj WLS	90
228		23. Sech Tuan Nala WLS	390
229		24. Shikari Devi WLS	30
230		25. Shimla Water Catchment WLS	10
231		26. Talra WLS	46
232		27. Tirthan WLS	61
233		28. Tundah WLS	64
234	Jammu & Kashmir (14)	1. Baltal-Thajwas WLS	211
235		**2. Gulmarg WLS**	180
236		**3. Hirapora WLS**	110
237		**4. Hokersar WLS**	14
238		5. Jasrota WLS	26
239		6. Lachipora WLS	80
240		7. Limber WLS	26
241		8. Nandni WLS	33
242		**9. Overa-Aru WLS**	425

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243		10. Rajparian (Daksum) WLS	20
244		11. Ramnagar Rakha WLS	32
245		**12. Tral WLS**	154
246		**13. Surinsar Mansar WLS**	56
247		14. Trikuta WLS	32
248	Ladakh (2)	**1. Changthang WLS**	4000
249		2. **Karakoram (Nubra Shyok) WLS**	5,000
250	Jharkhand (11)	**1. Dalma WLS**	193
251		2. Gautam Budha	121
252		**3. Hazaribagh WLS**	186
253		**4. Kodarma WLS**	177
254		5. Lawalong WLS	211
255		6. Mahuadanr Wolf WLS	63
256		**7. Palamau WLS**	753
257		8. Palkot WLS	183
258		9. Parasnath WLS	49
259		10. Topchanchi WLS	13
260		11. Udhwa Lake Bird WLS	6
261	Karnataka (35)	1. Adichunchunagiri Peacock WLS	0.84
262		**2. Arabithittu WLS**	13.5
263		**3. Attiveri Bird WLS**	2.23
264		**4. Bhadra WLS**	500.16
265		**5. Bhimgad WLS**	190.42
266		**6. Biligiri Rangaswamy Temple (B.R.T.) WLS**	539.52
267		**7. Brahmagiri WLS**	181.29
268		**8.** Bukkapatna WLS	136.11
269		9. **Cauvery WLS**	1027.53
270		10. Cauvery Extension	53.39
271		**11.** Chincholi WLS	134.88
272		**12. Dandeli WLS**	886.41
273		13. **Daroji Bear WLS**	82.72
274		14. Ghataprabha Bird WLS	29.78
275		15. Gudavi Bird WLS	0.73
276		**16.** Gudekote Sloth Bear WLS	47.61
277		17. Gudekote Extension WLS	120.05
278		**18.** Jogimatti WLS	100.48
279		19. Kamasandra WLS	78.62
280		20. Kappathagudda WLS	244.15
281		**21. Malai Mahadeshwara WLS**	906.187
282		**22.** Melkote Temple WLS	49.82
283		23. **Mookambika WLS**	370.37

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284		24. Nugu WLS	30.32
285		25. Pushpagiri WLS	102.92
286		26. **Ranebennur Black Buck WLS**	119
287		27. **Ranganathittu Bird WLS**	0.67
288		28. Ramadevara Betta Vulture WLS	3.46
289		29. Rangayyanadurga Four-horned antelope	77.23
290		30. Sharavathi Valley WLS	930.16
291		31. Shettihalli WLS	395.6
292		32. Someshwara WLS	314.25
293		**33. Talakaveri WLS**	105.59
294		34. Thimlapura WLS	50.86
295		**35. Yadahalli Chinkara WLS**	96.36
296	Kerala (18)	**1) Aralam WLS**	55
297		2) Chimmony WLS	85
298		**3) Chinnar WLS**	90
299		4) Chulannur Peafowl WLS	3.4
300		**5) Idukki WLS**	70
301		6) Karimpuzha	227
302		7) Kottiyoor WLS	30
303		**8) Kurinjimala WLS**	32
304		9) Malabar WLS	74
305		10) Mangalavanam Bird WLS	0.03
306		**11) Neyyar WLS**	128
307		**12) Parambikulam WLS**	285
308		13) Peechi-Vazhani WLS	125
309		14) Peppara WLS	53
310		**15) Periyar WLS**	427
311		**16) Shendurney WLS**	100
312		17) Thattekad Bird WLS	25
313		**18) Wayanad WLS**	344
314	Lakshadweep	Pitti (Bird Island) WLS	0.01
315	Madhya Pradesh (25)	1. Bagdara WLS	478
316		**2. Bori WLS**	486
317		**3. Gandhi Sagar WLS**	369
318		4. Ghatigaon WLS	511
319		5. Karera WLS	202
320		**6. Ken Gharial WLS**	45
321		7. Kheoni WLS	123
322		8. Narsighgarh WLS	59
323		**9. National Chambal WLS**	435
324		10. Noradehi WLS	1,195
325		11. Orcha WLS	45

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326		**12. Pachmarhi WLS**	418
327		13. Kuno WLS	345
328		14. Panna (Gangau) WLS	68
329		15. Panpatha WLS	246
330		**16. Pench WLS**	118
331		17. Phen WLS	111
332		18. Ralamandal WLS	2.4
333		**19. Ratapani WLS**	824
334		20. Sailana WLS	13
335		**21. Sanjay Dubari WLS**	365
336		22. Sardarpur WLS	348
337		23. Singhori WLS	288
338		**24. Son Gharial WLS**	42
339		25. Veerangna Durgavati WLS	24
340	Maharashtra (48)	1. Amba Barwa WLS	127
341		**2. Andhari WLS**	509
342		3. Aner Dam WLS	83
343		4. Bhamragarh WLS	104
344		**5. Bhimashankar WLS**	131
345		**6. Bor WLS**	61
346		7. Chaprala WLS	135
347		8. Deulgaon-Rehekuri WLS	2.2
348		9. Dhyanganga WLS	205
349		10. New Maldhok Bird (Gangewadi) WLS	2.0
350		11. Gautala-Autramghat WLS	261
351		12. Ghodazari WLS	159
352		**13. Great Indian Bustard WLS**	367
353		14. Isapur WLS	38
354		**15. Jaikwadi WLS**	341
355		**16. Kalsubai Harishchandragad WLS**	362
356		**17. Karnala Fort WLS**	4.5
357		18. Karanja Sohal Blackbuck WLS	18
358		19. Katepurna WLS	74
359		20. Koka WLS	100
360		**21. Koyana WLS**	424
361		**22. Lonar WLS**	1.2
362		23. Malvan Marine WLS	29
363		24. Mansingdeo WLS	183
364		25. Mayureswar Supe WLS	5
365		**26. Melghat WLS**	779
366		**27. Nagzira WLS**	153

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367		28. Naigaon Peacock WLS	30
368		**29. Nandur Madhameshwar WLS**	100
369		**30. Narnala Bird WLS**	12
370		**31. Nawegaon WLS**	123
371		**32. New Bor WLS**	61
372		**33. New Nagzira WLS**	151
373		**34. Painganga WLS**	325
374		35. Phansad WLS	70
375		**36. Pranhita WLS**	420
376		**37. Radhanagari WLS**	351
377		38. Sagareshwar WLS	11
378		39. Sudhagad WLS	77
379		40. Tamhini WLS	50
380		41. Tansa WLS	305
381		42. Thane Creek Flamingo WLS	17
382		43. Tipeshwar WLS	149
383		44. Tungareshwar WLS	85
384		45. Umred-Kharngla WLS	178
385		46. Wan WLS	22
386		47. Yawal WLS	189
387		48. Yedsi Ramlin Ghat WLS	211
388	Manipur (7)	1. Yangoupokpi Lokchao	184.4
389		2. Khongjaingamba Ching	0.412
390		3. Jiri Makru	198
391		4. Kailam	187.5
392		5. Zeilad	21
393		6. Bunning	115.8
394		7. Thinungei Bird	1.031
395	Meghalaya (4)	1. Baghmara Pitcher Plant WLS	0.02
396		2. Narpuh WLS	60
397		3. Nongkhyllem WLS	29
398		4. Siju WLS	5
399	Mizoram (9)	1. Buhuvum	94
400		**2. Dampa WLS**	500
401		3. Khawnglung WLS	35
402		4. Lengteng WLS	60
403		5. Ngengpui WLS	110
404		6. Pualreng WLS	50
405		7. Tawi WLS	36
406		8. Thorangtlang WLS	50
407		9. Tokalo WLS	250

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408	Nagaland (4)	1. Fakim WLS	6
409		2. Puliebadze WLS	9
410		3. Rangapahar WLS	4.7
411		**4. Singphan WLS**	23.5
412	Odisha (19)	1. Badrama WLS	304
413		2. Baisipalli WLS	168
414		3. Balukhand Konark WLS	72
415		**4. Bhitarkanika WLS**	525
416		**5. Chandaka Dampara WLS**	176
417		**6. Chilika (Nalaban) WLS**	16
418		**7. Debrigarh WLS**	347
419		**8. Gahirmatha (Marine) WLS**	1,435
420		9. Hadgarh WLS	191
421		10. Kapilash WLS	126
422		11. Karlapat WLS	148
423		12. Khalasuni WLS	116
424		13. Kothagarh WLS	400
425		14. Kuldiha WLS	273
426		15. Lakhari Valley WLS	186
427		16. Nandankanan WLS	14
428		**17. Satkosia Gorge WLS**	746
429		**18. Simlipal WLS**	1,354
430		**19. Sunabeda WLS**	500
431	Puducherry	Oussudu WLS	3.9
432	Punjab (13)	**1. Abohar WLS**	187
433		2. Bir Aishvan WLS	2.6
434		3. Bir Bhadson WLS	10
435		4. Bir Bunerheri WLS	7
436		5. Bir Dosanjh WLS	5
437		6. Bir Gurdialpura WLS	6
438		7. Bir Mehaswala WLS	1.2
439		8. Bir Motibagh WLS	7
440		**9. Harike Lake WLS**	86
441		10. Jhajjar Bacholi WLS	1.2
442		11. Kathlaur Kushlian WLS	8
443		**12. Nangal WLS**	2.9
444		13. Takhni-Rehampur WLS	3.8
445	Rajasthan (25)	1. Bandh Baratha WLS	200
446		2. Bassi WLS	139
447		3. Bhensrodgarh WLS	229
448		4. Darrah WLS	81
449		5. Jaisamand WLS	52

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450		6. Jamwa Ramgarh WLS	300
451		**7. Jawahar Sagar WLS**	153
452		8. Kailadevi WLS	676
453		9. Kesarbagh WLS	15
454		10. Kumbhalgarh WLS	609
455		**11. Mount Abu WLS**	326
456		**12. Nahargarh WLS**	50
457		**13. National Chambal WLS**	275
458		14. Phulwari Ki Nal WLS	693
459		**15. Ramgarh Vishdhari WLS**	253
460		16. Ramsagar WLS	34
461		17. Sajjangarh WLS	5
462		**18. Sariska WLS**	219
463		19. Sawaimadhopur WLS	131
464		20. Sawai Man Singh WLS	103
465		21. Shergarh WLS	99
466		**22. Sitamata WLS**	423
467		23. Tal Chhapar WLS	7
468		24. Todgarh Raoli WLS	495
469		**25. Van Vihar WLS**	26
470	Sikkim (7)	1. Barsey Rhododendron WLS	104
471		2. Fambong Lho WLS	52
472		**3. Kitam Bird WLS**	6
473		4. Kyongnosla Alpine WLS	31
474		5. Maenam WLS	35
475		6. Pangolakha WLS	128
476		7. Shingba Rhododendron WLS	43
477	Tamil Nadu (30)	**1. Cauvery North WLS**	504
478		2. Chitrangudi Bird WLS	0.5
479		3. Gangaikondam Spotted Dear WLS	2.9
480		**4. Indira Gandhi (Annamalai) WLS**	841
481		**5. Kalakad WLS**	224
482		6. Kanjirankulam Bird WLS	1.0
483		7. Kanyakumari WLS	458
484		**8. Karaivetti Bird WLS**	4.5
485		9. Karikilli Birds WLS	0.6
486		10. Kodaikanal WLS	609
487		11. Koonthankulam-Kadankulam WLS	1.3
488		**12. Megamalai WLS**	269
489		13. Melaselvanoor-Keelaselvanoor WLS	6
490		14. Mudumalai WLS	218

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491		15. Mundanthurai WLS	567
492		16. Nellai WLS	357
493		**17. Oussudu Lake Bird Sanctuary**	3.3
494		**18. Point Calimere WLS**	17
495		19. Point Calimere Block-A & Block-B	124
496		**20. Pulicat Lake Bird WLS**	154
497		21. Sakkarakottai Bird Sanctuary	2.3
498		**22. Sathyamangalam WLS**	1,412
499		**23. Srivilliputhur Grizzled Squirrel WLS**	485
500		24. Theerthangal Bird Sanctuary	0.29
501		25. Udayamarthandapuram Lake WLS	0.5
502		26. Vaduvoor Birds WLS	1.3
503		27. Vedanthangal Lake Birds WLS	0.3
504		28. Vellanadu Blackbuck WLS	16
505		29. Vellode Birds WLS	0.8
506		30. Vettangudi Birds WLS	0.38
507	Telangana (9)	**1. Amrabad (Nagarjunasagar-Srisailam) WLS**	2,166
508		2. Eturnagaram WLS	806
509		**3. Kawal WLS**	892
510		4. Kinnersani WLS	635
511		5. Lanja Madugu Siwaram WLS	30
512		**6. Manjeera Crocodile WLS**	20
513		7. Pakhal WLS	860
514		**8. Pocharam WLS**	130
515		**9. Pranahita WLS**	136
516	Tripura (4)	1. Gumti WLS	390
517		2. Rowa WLS	0.9
518		**3. Sepahijala WLS**	13
519		**4. Trishna WLS**	163
520	Uttar Pradesh (26)	1. Bakhira WLS	29
521		2. Chandraprabha WLS	78
522		3. Dr. Bhimrao Ambedkar Bird WLS	4.3
523		**4. Hastinapur WLS**	2,073
524		5. Jai Prakash Narayan (Surhatal) Bird WLS	34
525		**6. Kaimur WLS**	501
526		**7. Katerniaghat WLS**	400
527		**8. Kishanpur WLS**	227
528		9. Lakh Bahosi Bird WLS	80
529		10. Mahavir Swami WLS	5
530		**11. National Chambal WLS (Gharial)**	635
531		12. Nawabganj Bird WLS	2.3

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532		13. Okhala Bird WLS	4.0
533		**14. Parvati Aranga WLS**	11
534		15. Patna WLS	1.1
535		**16. Pilibhit WLS**	603
536		17. Ranipur WLS	230
537		**18. Saman Bird WLS**	5
538		**19. Samaspur Bird WLS**	8
539		**20. Sandi Birds WLS**	3.1
540		21. Shekha Bird WLS	0.25
541		22. Sohagibarwa WLS	428
542		23. Sohelwa WLS	452
543		**24. Sur Sarovar Bird WLS**	4.0
544		25. Turtle WLS	7
545		26. Vijai Sagar WLS	2.6
546	Uttarakhand (7)	**1. Askot WLS**	600
547		2. Binsar WLS	47
548		**3. Govind Pashu Vihar WLS**	486
549		**4. Kedarnath WLS**	975
550		**5. Mussoorie WLS**	11
551		**6. Nandhaur WLS**	270
552		**7. Sonanadi WLS**	301
553	West Bengal (16)	1. Ballavpur WLS	2.0
554		2. Bethuadahari WLS	0.7
555		3. Bibhuti Bhusan WLS	0.6
556		**4. Buxa WLS**	268
557		5. Chapramari WLS	10
558		6. Chintamani Kar Bird WLS	0.07
559		7. Haliday Island WLS	6
560		8. Jorepokhri Salamander WLS	0.04
561		9. Lothian Island WLS	38
562		10. Mahananda WLS	158
563		11. Pakhi Bitan Bird WLS	14
564		12. Raiganj WLS	1.3
565		13. Ramnabagan WLS	0.14
566		14. Sajnakhali WLS	362
567		15. Senchal WLS	39
568		**16. West Sunderban WLS**	556
			1,18,920 km^2

37.5. Description of Major Wildlife Sanctuaries

37.5.1. Andaman & Nicobar Islands

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Barren Island WLS	• **Barren Island is the only active volcano in India**.
Narcondam Island WLS	• **Narcondam Island is a dormant volcano**.

37.5.2. Andhra Pradesh

Coringa WLS	• It is a part of the **Godavari estuary (delta)** • Vegetation: **mangroves** and dry deciduous tropical forest. • Avian Fauna: **white-backed vulture** (CR) and the **Indian vulture** (CR). • Major Fauna: sea turtle, **smooth-coated otter (VU), olive ridley sea turtles (VU), estuarine crocodile (saltwater crocodile – LC)**, etc.
Gundla Brahmeswaram WLS	• It is located in the southern periphery of **Nagarjunasagar-Srisailam Tiger Reserve** in the **Nallamala Hills**. • It has a significant **tiger** population.
Kambalakonda WLS	• It is located in **Vishakhapatnam**. • It is rich in biodiversity.
Koundinya WLS	• Located along the Andhra and TN border. • It is an important **elephant corridor**.
Kolleru WLS (Bird Sanctuary)	• Kolleru is a natural **eutrophic lake** situated between the river basins of the **Godavari** and the **Krishna**.
Krishna WLS	• It is a **mangrove wetland** located in the Krishna delta.
Nellapattu WLS (Bird Sanctuary)	• It is a bird sanctuary in Nellore district. • Avian Fauna: spot-billed pelicans, night heron, and little cormorant.
Pulicat Lake WLS (Bird Sanctuary)	• It is located in Nellore district of AP and Thiruvallur District of Tamil Nadu. • **Pulicat Lake** is the **second largest brackish-water eco-system in India** after **Chilka lake** in Odisha. • Avian fauna: flamingos, pelicans, storks, etc.
Rollapadu WLS (Bird Sanctuary)	• Located in the Kurnool district. • It was established to protect the **Great Indian Bustard (CR)** and the **Lesser Florican (EN).**
Sri Lankamalleswara WLS	• Located in the southern part of the **Nallamala Hills** (in Kadapa district). • The **river Penna** separates the **Nallamala Hills** from **Palkonda hills**. • The WLS is known for **Jerdon's courser bird (CR)**. • Threats: red sanders smuggling.
Sri Penusila Narasimha WLS	• Located in Nellore District. • Comprises a unique forest type viz. the **dry evergreen forests**. • Such vegetation is unique to the Coromandel Coast (**Tamil Nadu**, Puducherry and south-eastern Andhra Pradesh).

37.5.3. Arunachal Pradesh

Eagle Nest WLS	• It conjoins **Sessa Orchid Sanctuary** to the northeast and **Pakhui (Pakke) Tiger Reserve**

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	across the Kameng river to the east. • It is a part of the **Kameng Elephant Reserve**.
Dibang WLS	• It is located within **Dihang-Dibang Biosphere Reserve**. • Major Fauna: takin, red goral, **red panda**, etc.
Sessa Orchid WLS	• It conjoins **Eaglenest Wildlife Sanctuary** to the southwest. • It is the natural habitat for various orchids (a family of flowering plants).

37.5.4. Assam

Amchang WLS	• It is located on the eastern fringe of **Guwahati.** • It lies between **Guwahati & Pobitora WLS**.
Barail WLS	• Located in the **Barail Range of Assam**.
Barnadi WLS	• Situated on the foothills of the Himalayas bordering Bhutan. • It was established to protect the **hispid hare (EN)** and **pigmy hog (EN)**.
Burachapari WLS	• Situated on the south bank of the Brahmaputra River in Sonitpur district. • It is considered to be an ideal habitat for the **Bengal florican (CR)**.
Chakrasila WLS	• Situated close to the north bank of the Brahmaputra River in Dhubri district. • It is an important protected habitat for **golden langur (EN)** after **Manas NP**.
Deepor Beel WLS (Ramsar Site)	• It is a permanent freshwater lake in a former channel of the Brahmaputra river. • It is a few kilometres to the left of **Guwahati,** whereas **Pobitora Wildlife Sanctuary is around 35 km to the right**.
Dihing Patkai WLS	• It is situated on the **Assam-Arunachal border**. • The Dihing River originates in the **Patkai Bum Hills** (Arunachal Pradesh & Myanmar border) and flows through this WLS. • **It was recently upgraded to a National Park**.
East Karbi Anglong WLS	• It is near Diphu, the headquarter of East Karbi Anglong district.
Garampani WLS	• It is located adjacent to **Nambor WLS** in East Karbi Anglong district. • It contains **hot water spring** and waterfalls.
Hollongapar Gibbon WLS	• It contains India's only gibbons – the **hoolock gibbons (EN)**, and North-eastern India's only nocturnal primate – the **Bengal slow loris (**VU**)**. • Threats: **Tea gardens**.
Lawkhowa WLS	• It is situated between **Kaziranga NP** and **Orang NP** (north of Brahmaputra). • It is an ideal habitat for **Indian rhinoceros (VU)** and **Asiatic water buffaloes (EN)**.
Marat Longri WLS	• It is located a few kilometres to the north-west of Diphu. • It is an important component of **Dhansiri-Lungding Elephant Reserve**.
Nambor WLS	• It is located on the eastern periphery of the **Mikir Hills (Karbi Anglong Plateau)**.
Nambor-Doigrung WLS	• The sanctuary along with **Garampani WLS, Nambor WLS** are a part of the **Kaziranga-Karbi Anglong Elephant Reserve (East Karbi Anglong district)**.
Pabitora WLS	• It is about 30 km to the east of **Guwahati**. • **Pobitora (Mini Kaziranga)** has exceeded its rhino-bearing capacity. • Under the Indian Rhino Vision 2020 (IRV 2020) several rhinos were translocated from

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	Pobitora and **re-introduced** into the **Manas National Park**.
Pani-Dihing WLS (Bird Sanctuary)	• It is located in Sivasagar district. • It is about 50 km to the north-east of **Hollongapar Gibbon WLS**.
Sonai Rupai WLS	• It is located a few tens of kms to the west of **Pakke TR (Arunachal Pradesh)** and **Nameri NP (Assam)**.

37.5.5. Bihar

Barela Jheel Salim Ali Bird WLS	• It is also called as Salim Ali-Jubba Sahni Bird Sanctuary. • Braila Lake (Barela Jheel) is a natural home for migratory birds.
Bhimbandh WLS	• It is situated south of the Ganges River, at the northern edge of Chota Nagpur Plateau and west of Santhal Pargana.
Gautam Budha WLS	• It is located in Gaya district of Bihar and Koderma district of Jharkhand.
Kaimur WLS	• Located in the eastern part of the **Vindhyan Scrap Lands** in Kaimur District. • It is the largest sanctuary in the state and is a **tiger corridor**.
Kanwar Jheel WLS (Bird Sanctuary)	• The **Kanwar Lake** is located in Begusarai district. • It is Asia's largest freshwater **oxbow lake**. • It is larger than the **Bharatpur Bird Sanctuary (Keoladeo Ghana NP, Rajasthan)**. • Notable Avifauna: **White-backed vulture (CR)** & **Long-billed (Indian) vulture (CR).** • **It was recently included in the Ramsar List.**
Kusheshwar Asthan Bird WLS	• It is close to the right bank of **River Kosi (Sorrow of Bihar)** and is about 40 km to the north-east of **Kanwar Lake**.
Nagi Dam WLS (Bird Sanctuary) & Nakti Dam WLS (Bird Sanctuary) are located in Jamui District close to each other.	
Pant (Rajgir) WLS	• Located in the **ancient city of Rajgir in Nalanda district**.
Udaipur WLS	• Located in West Champaran district. • It is an **oxbow lake** in the floodplain of the **Gandaki River**.
Vikramshila Gangetic Dolphin WLS	• The WLS is a **60 km stretch of the Ganges River** from **Sultanganj to Kahalgaon** in **Bhagalpur District**. • Protected area for the India's **national aquatic animal** — **Gangetic dolphins (EN)**.

37.5.6. Chandigarh

City Bird WLS	• It is located in Chandigarh city. • It is also known as Parrot Bird Sanctuary as it is primarily a habitat of parrots.
Sukhna Lake WLS	• It is located in Shivalik foothills of Chandigarh city, near Sukhna Lake.

37.5.7. Chhattisgarh

Badalkhol WLS	• It is located in the Ramgarh Hills. • It is a tiger corridor between **Achanakmar TR (Chhattisgarh)** & **Palamau TR (Jharkhand)**.
Barnawapara WLS	• It is located in north-eastern Raipur District. • It is bounded by the **River Mahanadi** to the west and north and the **Jonk River (right bank tributary of Mahanadi)** to the east and northeast.

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Bhairamgarh WLS	• **Indravati River (right bank tributary of Godavari)** separates **Indravati NP** from Bhairamgarh WLS. • It was set up to protect the **Wild Asian Buffalo (EN)** species.
Bhoramdev WLS	• It is a tiger corridor in **Maikal Hills** (eastern part of **Satpura Range**) between **Kanha TR (MP)** and **Achanakmar TR (Chhattisgarh)**.
Sarangarh-Gomardha WLS	• It is about 100km to the east of Barnawapara WLS.
Pamed Wild Buffalo WLS	• Located in **Dantewada District**.

37.5.8. Goa

<table>
<tr><td>Dr. Salim Ali Bird (Chorao) WLS</td><td>
It is an estuarine mangrove habitat located on the Chorão Island along the Mandovi River.
</td></tr>
<tr><td>Madei WLS</td><td>

- It is being **considered to become a Tiger Reserve under Project Tiger**.
- Was in the news in Jan 2020 when a Royal Bengal tigress and her cubs were poisoned by villagers due to human-animal conflict.
- Madei WLS has been declared an International Bird Area.
- The **Mhadei River** passes through the Mhadei WLS and meets the Sea at Panaji.
- **Panaji** is situated on the left bank of the **Mandovi**.
- The river originates from springs at **Bhimgad** in the **Belagavi district** of Karnataka.
- **Mandovi** joins with the **Zuari** at a common creek, forming the **Mormugao harbour**.
- The **Mhadei River (in Karnataka)**, known downstream as the **Mandovi River (in Goa)**, the **lifeline of the state of Goa**.
- The river has a length of 81 kilometres, 35 kilometres in Karnataka, 1 kilometre in Maharashtra and 45 kilometres in Goa.

Mahadayi Water Dispute

- The sharing of the waters of the **Mhadei (Mahadayi, Mandovi) River** is a cause of dispute between **Karnataka** and **Goa**.
- The Karnataka government proposes to divert some water from the Mahadayi river to the **Malaprabha River basin** as part of the **Kalasa-Banduri Nala project** (drinking water supply to the Districts of Belagavi, Bagalkot, Dharwad and Gadag in Karnataka).
- The issue of water sharing is now in the Supreme Court.

</td></tr>
</table>

37.5.9. Gujarat

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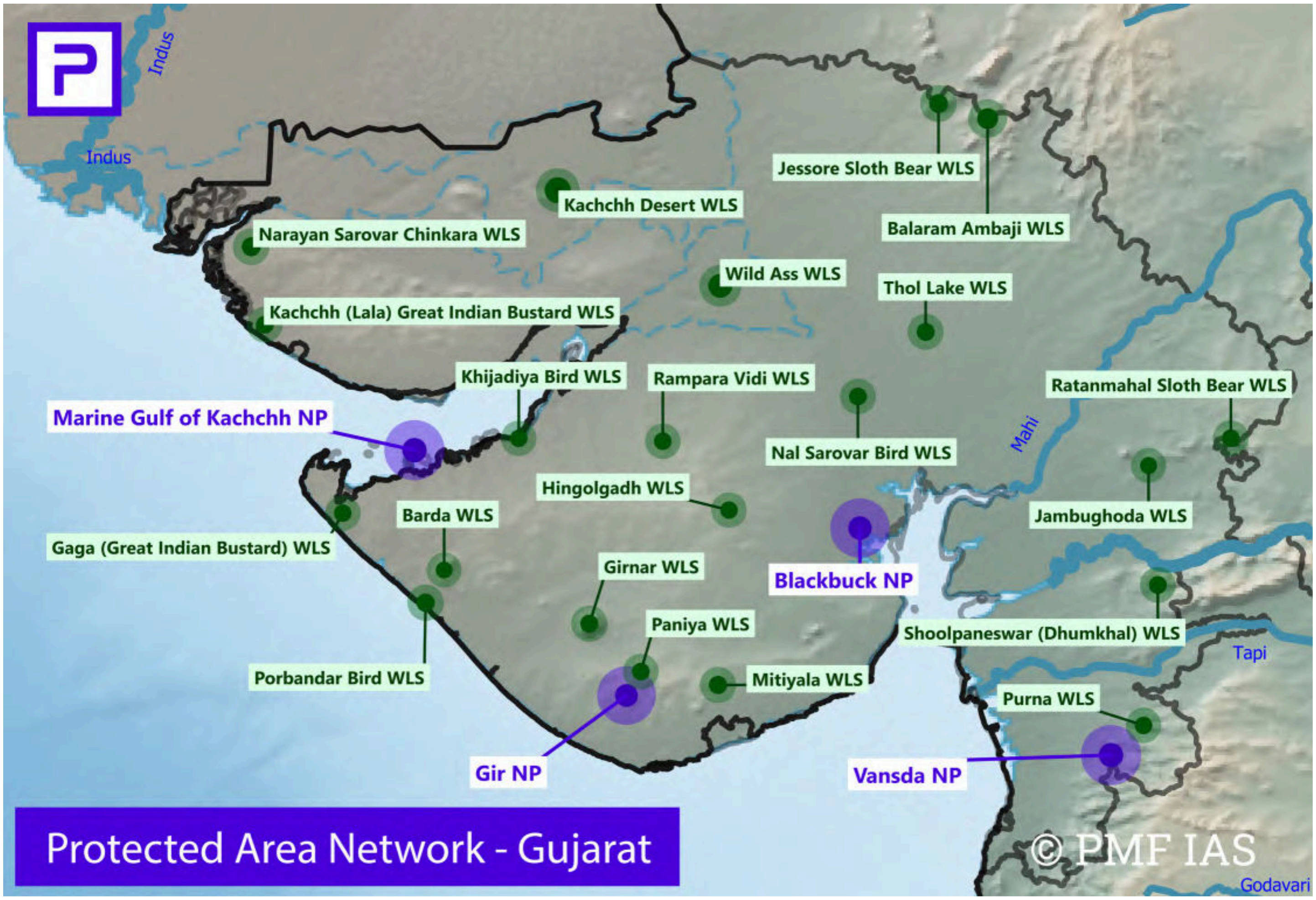

Balaram Ambaji WLS	• It is located ~50 km to the south of **Mt. Abu (in Aravallis)** at the Rajasthan border. • Major Fauna: sloth bear, striped hyena, Indian leopard, Nilgai (blue bull), Indian porcupine, small Indian civet, Indian pangolin, etc.
Barda WLS	• Located near Porbandar. • It was a previous range of Asiatic lions.
Gaga (Great Indian Bustard) WLS	• Situated in the Saurashtra peninsula on the coast of the Gulf of Kutch. • Three Indian bustard species: 1. **Great Indian Bustard (CR) –** restricted to isolated pockets in **Andhra Pradesh, Gujarat, Karnataka**, and **Rajasthan** 2. **Lesser florican (EN)** – central and western India. 3. **Bengal florican (CR) – Terai of Nepal to Arunachal Pradesh in India.**
Girnar WLS	• Located in the **Girnar Hills in Junagadh district**. • The city of **Junagadh** is located on the western flank of the Girnar WLS. • Girnar forests were once part of a major forest ecosystem comprising of Gir and Girnar. • Gradually the urbanization and agricultural expansion have isolated these two forests. • **Asiatic lions (EN)** strolling out of the Girnar WLS (into Junagadh) is a common sight.
Jessore Sloth Bear WLS	• It is located ~50 km to the south of **Mt. Abu** in the Banaskantha district at the Rajasthan border. • It was declared as a sanctuary for the protection of the **sloth bear (VU)**. • The **Banas River** separates Jessore Sloth Bear WLS (west) from Balaram Ambaji WLS

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	(east).
Kachchh (Lala) Great Indian Bustard WLS	• Along with Kutch Bustard Sanctuary, Gaga WLS is one of two **great Indian bustard** sanctuaries in Gujarat.
Kachchh Desert WLS	• It situated in the Great Rann of Kutch. • It is the **largest Wildlife Sanctuary in India area wise**. • It is a shallow seasonal saline wetland. • Major Avifauna: **greater flamingos** nest in the mud flats of the Rann. • **Fossils of dinosaurs and crocodiles** have been recovered from here.
Khijadiya Bird WLS	• It is a bird sanctuary located in Jamnagar district.
Mitiyala WLS	• It is a grassland with semi-dry deciduous trees. • It is almost like an offshoot of Gir Lion Sanctuary.
Nal Sarovar Bird WLS	• It is a **Ramsar Site**. • It is a **natural freshwater lake (a relict sea)** in the Thar Desert. • The wetland is a lifeline for a satellite population of the **Indian Wild Ass (NT)** & blackbuck. • It is situated about 60 km to the west of Ahmedabad. • It is inhabited by migratory birds in winter and spring. • Avifauna: flamingoes, white storks, herons, migratory waterfowls, etc.
Narayan Sarovar Chinkara WLS	• Narayan Sarovar is located near the **Kori Creek**. • Narayan Sarovar Sanctuary and **Banni Grasslands**, both in Kutch, have been proposed as some of the possible sites for the **reintroduction of the Asiatic Cheetah** in India. • **Asiatic cheetah (CR)** that used to occur here are now **locally extinct in India** and elsewhere, except a small population thought to be surviving in the **central desert of Iran**.
Porbandar Bird WLS	• It lies in the heart of city of Porbandar.
Purna WLS	• It derives its name from the Purna River, which flows through it. • It is located in the Western Ghats in the States of Gujarat and Maharashtra. • It is adjacent to the **Vansda (Bansda) National Park**.
Ratanmahal Sloth Bear WLS	• Located in the Dahod district.
Shoolpaneswar (Dhumkhal) WLS	• It located in the **western Satpura Range** south of the **Narmada River**. • It shares a common boundary with Madhya Pradesh and Maharashtra. • The **River Tapti** separates Shoolpaneswar WLS (north) from Purna WLS (south).
Thol Lake WLS	• Thol Lake (in Mehsana dt) is a manmade reservoir situated 25 km northwest of Ahmedabad. • It is the most popular birding place near Ahmedabad after Nal Sarovar. • Major Avifauna: flamingos, **sarus cranes**, great white pelicans, **white-rumped vulture, Indian vulture**, etc.
Wild Ass WLS	• It is located in the **Little Rann of Kutch**. • It is the only place where the **Indian Wild Ass (NT)** can be spotted. • Threats: illegal salt panning.

37.5.10. Haryana

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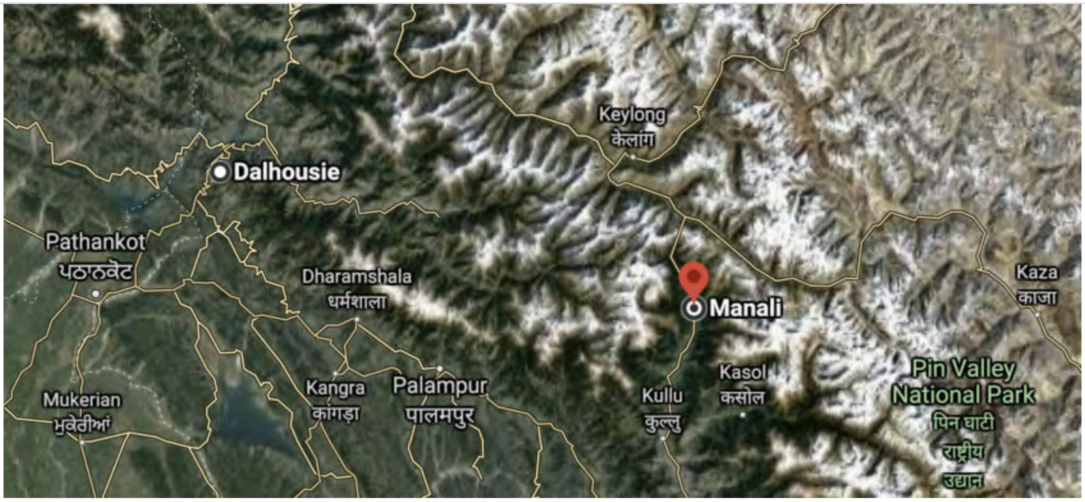
Bir Shikargarh WLS	• Morni Hills (Khol-Hi-Raitan) WLS and Bir Shikargah WLS are only 3 kilometres from each other. • Both lie in the **Shivalik hills** of Haryana.
Chhilchhila Lake WLS	• It is also known as Seonthi Reserve Forest. • It is located near Kurukshetra University in Kurukshetra district.
Khaparwas WLS	• It is a bird sanctuary in Jhajjar district.

37.5.11. Himachal Pradesh

Chandratal WLS (Ramsar Site)	• Chandra Tal (crescent shape) is a lake in the **Spiti part of the Lahul and Spiti district**. • It is at an altitude of about 4,300 metres in the Himalayas. • It is accessible on foot from **Kunzum Pass**. • The **Kunzum Pass** connects Lahul valley and Spiti valley.
Churdhar WLS	• It is located in Sirmour, Shimla district. • It is named after Churdhar Peak (3,647).
Dhauladhar WLS	 • The **Dhauladhar range** (lies almost entirely in HP) is a part of the **Lesser (Middle) Himalayas**. • It lies between **Dalhousie (near Ravi River)** and the **Kullu-Manali Valley (Beas River)**. • The **Ravi River** flows along the western and the northern fringes of the Dhauladhar range. • **Dharamsala**, the headquarters of Kangra district, lies on the southern slope of the Dhauladhar range in the **Kangra Valley** (strike valley that extends from the foot of the Dhauladhar range to the south of river Beas). • The elevation of the Dhauladhars ranges widely from 3,500 m to nearly 6,000 m. • **Hanuman Tibba** at 5,982 meters stands as the highest peak of the Dhauladhar range. • The forested region is at the foot of the Dhauladhar Range. • Major Flora: Oak, Rhododendron, Deodar, etc.
Kais WLS	• It lies in the **Kullu district**. • This high altitude sanctuary includes parts of the Kais Nala (a tributary of the River Beas). • It was declared mainly to protect the **Musk Deer (EN)**. • The musk Deer population has declined drastically **due to poaching for its musk pod**.
Kalatop-Khajjiar WLS	• It lies in the path of the **Ravi River** near **Dalhousie** (Western tip of the Dhauladhar

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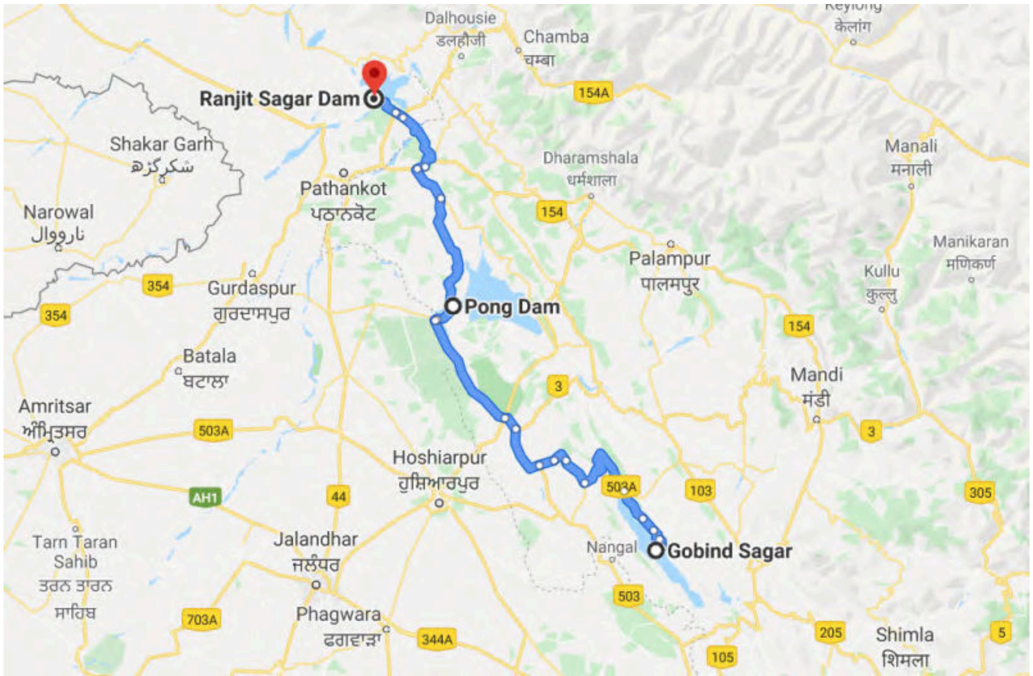
	Range). • Vegetation: dense deodar and fir forest.
Kibber WLS	• It is located high in the Spiti Valley in the Himalayas at 3600-4000 metres. • Vegetation is sparse.
Kugti WLS	• It is situated at an altitude ranging from 2,195-5,040 m between Ravi and Chenab Rivers. • Major Fauna: **Himalayan tahr (NT)**.
Lippa Asrang WLS	• Located in Kinnaur district. • **Snow Leopards (VU)** are found at altitudes of 4000m.
Manali WLS	• Manali River (right bank tributary of Beas River) passes through this WLS.
Pong Dam Lake WLS (Ramsar Site)	• **Maharana Pratap Sagar (Pong Reservoir or Pong Dam Lake)** was created on the **Beas River in Kangra district**.  • The reservoir was declared as a **bird sanctuary**. • The **Pong Reservoir** and **Gobindsagar Reservoir (on Sutlej River)** are the two most important fishing reservoirs in the Himalayan foothills of Himachal Pradesh. ✓ **Ranjit Sagar dam (Ranjit Sagar Lake in Punjab) ⟶ Ravi River** ✓ **Pong dam (Maharana Pratap Sagar) ⟶ Beas River** ✓ **Bhakra dam (Gobindsagar Reservoir) ⟶ Sutlej River**
Rakchham Chitkul (Sangla Valley) WLS	• It is located 30 km to the north of **Govind NP (Uttarakhand)** in the Sangla Valley (The River Baspa that flows through this valley is a tributary of **River Sutlej**).
Renuka WLS (Ramsar Site)	• A small tributary of the Yamuna separates the Renuka WLS (north) from **Simbalbara NP**.
Rupi Bhaba WLS	• It is located in the Kinnaur district along the right bank of the Sutlej River between **Pin Valley NP** and **Govind NP (Uttarakhand)**.
Sech Tuan Nala WLS	• It lies in the Chamba district (Chamba wildlife division).
Shikari Devi WLS	• It lies in the Mandi District. The Sutlej River flows south of Shikari Devi WLS.

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37.5.12. Ladakh UT

Changthang WLS	• It is located in the Ladakhi **Changthang Plateau** in the Leh district. • It has **one of the highest lakes on earth**, **Tso Moriri (4595 m – Ramsar Site)**. • **Korzok monastery** (Korzok village) is located on the north-western bank of Tso Moriri. • Major Fauna: snow leopard, **kiang or Tibetan Wild Ass (LC)**, **argali or Great Tibetan Sheep (NT)**, dark-necked crane, etc.
Karakoram (Nubra Shyok) WLS	• High altitude WLS located in the easternmost reaches of the **Karakoram range in Leh district**. • It is one of the few places with a migratory population of the **Chiru/Tibetan Antelope (NT)**.

37.5.13. Jammu & Kashmir UT

Gulmarg WLS	• It is located 40 km to the west of Srinagar in the **foothills of Pir Panjal Range**. • Major Fauna: **musk deer, common leopard, barking deer**, etc.
Hirapora WLS	• Located in Shopian district of Kashmir, 70 km south of Srinagar. • On the west, it is bounded by **Pir Panjal pass** (60 km to the south-west of Srinigar).
Hokersar WLS (Ramsar Site)	• **Hokersar (Hokera) Wetland** is natural perennial wetland contiguous to the **Jhelum basin**. • **Hokersar** is located 10 km to the west of **Srinagar** whereas **Dal Lake** is located to the east. • **Hokersar** is close to the south bank of Jhelum whereas **Dal Lake** is close to the north bank. • It is an important migratory bird area.
Jasrota WLS	• It is located in the Sivalik Hills ~40 km to the west of **Ranjit Sagar Dam** (Punjab).
Nandni WLS	• It is near Jammu. • The site is primarily a bird sanctuary that is known for its **pheasant** population.
Overa-Aru WLS	• It is located near Pahalgam district with mountains peaking up to 5,400 m. • It is located less than 80 km to the east of **Dachigam NP**. • Major fauna: **hangul (Kashmir Stag – CR), musk deer (EN), snow leopard (VU),** etc.
Rajparian (Daksum) WLS	• It is located in Anantnag district of Kashmir. • Major fauna: **hangul (Kashmir Stag – CR), musk deer (EN)**, etc. • The sanctuary is disturbed due to excessive grazing by the livestock of nomadic **Bakarwals**. • The Bakarwal nomads are based in the Pir Panjal and Himalayan mountains. • As sheep and goat rearing **transhumants**, the **Bakarwal** alternate with the seasons between high and low altitudes in the hills of the Himalayas.
Ramnagar Rakha WLS	• It is at a distance of 6 km from Jammu. • Major fauna: **musk deer**, brown bears, leopards, etc.
Surinsar Mansar WLS (Ramsar Site)	• It derives its name from the two lakes, located on each corner of the sanctuary. • It is located 58 kms away from the Jammu city.
Tral WLS	• It is situated in Pulwama district.

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	• Created in 2019 to conserve **hangul (Kashmir Stag – CR)** • It will act as a buffer around the **Dachigam National Park** and Overa-Aru WLS.
Trikuta WLS	• Trikuta (three-peaked) mountain 50 km to the north of Jammu hosts the highly revered **Vaishno Devi shrine**.

37.5.14. Jharkhand

Dalma WLS	• It is located 10 km to the north of Jamshedpur in the **Dalma Hills (southern Jharkhand)**. • It is an important **elephant corridor**.
Gautam Budha WLS	• Located in Gaya district of Bihar and Koderma district of Jharkhand. • It covers the Lower Gangetic Plains moist deciduous forests and Chota Nagpur dry deciduous forests ecoregions.
Hazaribagh WLS	• It is located about 89 km north of Ranchi.
Kodarma WLS	• It is adjacent to Gautam Budha WLS.
Lawalong WLS	• It is contiguous with the Gautam Budha WLS and Kodarma WLS along the **Bihar-Jharkhand border**.
Mahuadanr Wolf WLS	• Located in the Latehar district along the Jharkhand-Chhattisgarh border. • It is a breeding ground for Indian Wolf.
Palkot WLS	• Located at Palkot in Gumla district and Simdega district of Jharkhand. • It is contiguous with the Koel River Valley forests, **Saranda-Singhbhum Range forests** and Dalma WLS.
Parasnath WLS	• Situated in the Parasnath Hills (eastern end of Chota Nagpur Plateau) in the Giridih district.
Topchanchi WLS	• It is adjacent to the Parasnath WLS.
Udhwa Lake Bird WLS	• It is the only bird sanctuary of Jharkhand state. • It comprises two backwater lakes over river **Ganges** (Ganga).

37.5.15. Karnataka

Adichunchunagiri WLS	• Adichunchunagiri Peacock WLS is located in Mandya district.
Arabithittu WLS	• Located in Mysore district.
Attiveri Bird WLS	• Located in Uttara Kannada district.
Bhimgad WLS	

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	• Located in the **Western Ghats of Belgaum District**. • The Bhimgad forests are notable for the only known breeding area of the **Wroughton's free-tailed bat (CR)**. • The sanctuary is contiguous to the east of **Mhadei WLS (Goa)**, north-west of the **Bhagwan Mahaveer WLS and Mollem NP (Goa)** and north of **Dandeli WLS (Karnataka)**.
Brahmagiri WLS	• It is located in the Kodagu (Coorg) district and is part of the Western Ghats. • Brahmagiri WLS (north) is contiguous with the **Aralam WLS (south) of Kerala**. • Major Fauna: **lion-tailed macaque (EN)**, elephant, gaur, tiger, sambar, spotted deer, **Nilgiri langur**, slender loris, bonnet macaque, barking deer, mouse deer, **Malabar giant squirrel**, **giant flying squirrel, Nilgiri marten**, etc.
Bukkapatna	• It is a recently declared **chinkara sanctuary** in Tumakuru district.
Cauvery WLS	• It is located in the Mandya, Chamarajanagar and Ramanagar districts. • It is contiguous with the **BR Hill TR (Karnataka), Sathyamangalam TR (TN)** and **Dharmapuri forest division (TN)**. • **Hogenakal Falls, Mekedatu** (confluence of Cauvery with the **Arkavathi River**) are the important locations in the Cauvery WLS. • Major Fauna: tiger, elephant, barking deer, sambar, four-horned antelope, Malabar giant squirrel, grizzled giant squirrel, smooth-coated otter, **mugger crocodile**, etc.
Chincholi WLS	• It is a dryland WLS in Kalburgi District.
Daroji Bear WLS	• It is located 15 km from the **World Heritage Site of Hampi** in Bellary district. • The sanctuary was created exclusively for the preservation of the **sloth bear** (VU).
Ghataprabha Bird WLS	• Its boundaries enclose a stretch of about 28 km of the **Ghataprabha River (a right-bank tributary of the Krishna River)** near Belagavi.
Gudavi Bird WLS	• It is a small seasonal lake located in Shimoga District.
Gudekote Sloth Bear WLS	• It is located in Bellary district. • The sanctuary was created exclusively for the preservation of the sloth bear. • It is about 80 km to the south of Daroji Sloth Bear Sanctuary.
Jogimatti WLS	• Jogimatti is a hill station and forest reserve in Chitradurga district.
Kamasandra WLS	• It is recently declared WLS. It is located in Kolar district (KA, AP & TN trijunction).
Kappathagudda WLS	• A forest in Gadag district facing a serious threat from illegal mining.
Malai Mahadeshwara WLS	• It is located in the **Eastern Ghats** in the Chamarajanagar district. • It has **Cauvery Wildlife Sanctuary (Karnataka)** to its North and East, **Sathyamangalam Tiger Reserve (Tamil Nadu)** to its South and **Biligirirangaswamy Temple Tiger Reserve (Karnataka)** to its West.
Melkote Temple WLS	• It is situated in Mandya district. • It was declared as a sanctuary to protect the habitat of Grey Wolf.
Mookambika WLS	• It derives its name from the **Kollur Mookambika Temple**. • The sanctuary lies in the **Western Ghats in Udupi district**. • The famous **Kodachadri Hills** are located in the sanctuary.
Nugu WLS	• It is situated north of **Bandipur National Park** in Mysore district.

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Pushpagiri WLS	• It is located in Somwarpet taluk of the Kodagu district. • **Pushpagiri (Kumara Parvatha – 1712 m)** is the highest peak in it. • The sanctuary **Kukke Subramanya** forest range to the west.
Ranebennur Black Buck WLS	• It is situated in Haveri district. • It was declared as a sanctuary mainly to protect **blackbucks (LC)**. • A small number of **great Indian bustards** were observed here.
Ranganathittu Bird WLS	• It is situated in the Mandya District. • It is the largest bird sanctuary in the state and comprises six **islets on the banks of the Cauvery River**. • **Ranganathittu** is located near the historic town of **Srirangapattana (near Mysore)**. • The sanctuary experiences heavy flooding when water is released from **Krishna Raja Sagara dam (on Cauvery River)** upstream, due to heavy rains. • Major Fauna: smooth coated otter, common palm civet, **mugger crocodile**. • During winter months thousands of birds congregate at Ranganathittu, some migrating from Siberia, Latin America and parts of north India. • Major avifauna: painted stork, Asian openbill stork, common spoonbill, woolly-necked stork, black-headed ibis, etc.
Ramadevara Betta Vulture WLS	• Ramadevara betta is a hill in the Ramanagara district. • It houses the endangered **Long-billed vulture (Indian Vulture – CR), Egyptian Vulture (EN) and White-rumped vulture (CR)**.
Rangayyanadurga Four-horned antelope	• It is located in Davanagere district. • The only sanctuary for **four-horned antelopes (chausingha – VU)** in Karnataka.
Sharavathi Valley WLS	• It is located to the north of Mookambika WLS. • Sharavati is westward flowing river that lies entirely in the Western Ghats. • The famous **Jog Falls** are formed by this river. • **Linganamakki Reservoir** is a major part of the Sharavati Valley.
Shettihalli WLS	• It is located in Shimoga district. • It is contiguous with the **Bhadra WLS and TR**. • The **Mandagadde Bird Sanctuary** near Tunga Gajanur Dam is a part of the Shettihalli WLS.
Someshwara WLS	• The **Sharavathi Valley WLS (north), Mookambika WLS** and **Someshwara WLS** (south) are a contiguous stretch of Western Ghats to the west of **Bhadra WLS & TR**. • **Agumbe (The Cherrapunji of South India)** is located in this WLS.
Yadahalli Chinkara WLS	• It is WLS for **chinkaras (Indian Gazelle – LC)** at Yadahalli in Bagalkot district.
Talakaveri WLS	• Talakaveri is the place considered to be the source of the river Kaveri. • It is located on **Brahmagiri hills** in Coorg district.
Thimlapura WLS	• It is a conservation reserve for bears in Tumkur district.
Yadahalli WSL	• **Chinkara sanctuary** in Baglkot district.

37.5.16. Kerala

Aralam WLS	• It is located on the **western slope of the Western Ghats in the Kannur District**. • Aralam WLS (south) is contiguous with the **Brahmagiri WLS (north) of Karnataka**.

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	• **Nagarhole NP and TR** lies to the east of Aralam WLS.
Chimmony WLS	• It is located along the Western Ghats in Thrissur District. • It is contiguous with the Peechi-Vazhani WLS and **Parambikulam WLS & TR**. • Nestled in the sanctuary is **Chimmony Dam** which is built across the Chimmony river.
Chinnar WLS	• It is located in the **Idukki district**. • It is contiguous with **Eravikulam NP** to the south, **Indira Gandhi WLS (Anamalai TR & NP)** is to the north and **Kodaikanal (Palani Hills)** is to the east. • It forms an integral part of the protected forests straddling the Kerala-Tamil Nadu border in the **Anaimalai Hills**. • The Western Ghats, Anamalai Sub-Cluster, including all of Chinnar WLS, is **under consideration by the UNESCO for selection as a World Heritage Site**. • The Chinnar and Pambar rivers are the major perennial water resources in the sanctuary. • The Chinnar follows the interstate boundary along the northwest edge of the sanctuary for and becomes the **Amaravati River in Tamil Nadu**. • The Pambar River originates in the Anaimudi Hills, traverses the Eravikulam NP and joins the Chinnar River. • **Albino gaur (Manjampatti white bison)** are rare and are found only in **Indira Gandhi WLS** and **Chinnar WLS**.
Chulannur Peafowl WLS	• It is located in the **Pal Gap/ Palghat Gap/Palakkad Gap** in Palakkad district. • It is famous for peacocks.
Idukki WLS	• It is cradled by the **Cheruthoni** (tributary of the Periyar River) and **Periyar Rivers**. • It is located to the northwest of **Periyar TR** and to the southwest of **Mathikettan NP**. • **Cardamom Hills** lie between Mathikettan NP and Idukki WLS. • Periyar River originates near **Periyar TR**, flows from **Mullaperiyar Dam** to the **Idukki Reservoir**, flows entirely through Kerala and **joins the sea in the Kerala**.
Kottiyoor WLS	• Situated in eastern hilly area of Kannur. • Kottiyoor WLS is adjacent to **Aralam WLS** (north) and **Nagarhole NP** (east).
Kurinjimala WLS	• It protects the core habitat of the endangered **Neelakurinji plant** in Idukki district. • It is contiguous to the **Chinnar WLS** to the northwest, **Eravikulam NP & Anamudi NP** to the west, **Pampadum Shola NP** to the south and the proposed **Palani Hills** NP to the east. • **Neelakurinji** is a shrub that is found in the **shola forests** of the Western Ghats. • **Nilgiri Hills**, which literally means the **blue mountains**, got their name from the **purplish blue flowers of Neelakurinji** that **blossoms only once in 12 years**.
Malabar WLS	• It is located along the Western Ghats in Kozhikode district. • It is a part of **Nilgiri Biosphere Reserve** and **Wayanad Elephant Reserve**.
Mangalavanam Bird WLS	• It is situated at the centre of the Indian city of **Kochi**. • It attracts a large variety of migratory birds and supports many types of mangroves. • Maradu municipality of **Kochi** was in news due to the demolition of illegal high rise buildings constructed on the banks of **Vembanad lake (Ramsar Site).** • **Vembanad lake** is the largest lake of Kerala, spanning across **Alappuzha, Kottayam, and Ernakulam districts**. • It is the **second largest Ramsar Site** in India after **Sundarbans**.

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	• It is also the **longest lake in India**. • It is **below sea level** and is famous for exotic fish varieties and **Paddy fields that are below sea level**.
Neyyar WLS	• It is spread over the southeast corner of the Western Ghats. • This is the drainage basin for the Neyyar River and **Neyyar Dam**. • It lies to the west of **Agasthyamalai** (1868 meters). • This peak is a part of the **Agasthyamala Biosphere Reserve,** which lies on the border between Kerala and Tamil Nadu.
Peechi-Vazhani WLS	• It is located in Thrissur District. • It consists of **Palappilli-Nelliyampathi forests,** including the area of Chimmony WLS. • **Chimmony WLS** is contiguous with the Peechi-Vazhani WLS and **Parambikulam TR**.
Peppara WLS	• It is located to the north of **Neyyar WLS** and west of **Agasthyamalai.**
Shendurney WLS	• It is located in Kollam district. • It comes under the control of Agasthyamalai Biosphere Reserve. • It lies to the northeast of Peppara WLS.
Thattekad Bird WLS	• It is located in the Ernakulam district. • It is an evergreen low-land forest located between the branches of the **Periyar River**.
Wayanad WLS	• It is located in Wayanad district. • It an integral part of the **Nilgiri Biosphere Reserve**. • It is bounded by **Nagarhole and Bandipur NPs** of Karnataka in the northeast, and on the southeast by **Mudumalai NP**. • It is a major elephant and tiger corridor.

37.5.17. Lakshadweep

Pitti (Bird Island) WLS	• It is an uninhabited coral islet in Lakshadweep. • It is located about 24 km to the north of **Kavaratti**.

37.5.18. Madhya Pradesh

Bagdara WLS	• It is located near the **Ban Sagar Dam** in the Sidhi District. • **Ban Sagar Dam** is a multipurpose river Valley Project on **Sone River**.
Bori WLS	• It is located in Hoshangabad District in the northern foothills of the **Satpura Range**. • It is bounded by the **Satpura NP** to the north and east, and by the **Tawa River (tributary of Narmada)** to the west. • The sanctuary, together with **Satpura NP** and the **Pachmarhi WLS**, forms the **Pachmarhi Biosphere Reserve**.
Gandhi Sagar WLS	• It is located 70 km to the west of **Mukundara Hills NP & TR**. • It is located between **Gandhi Sagar Dam of MP** and **Rana Pratap Sagar Dam of Rajasthan**. • Both the dams are built on the **Chambal River.** • **The Chambal River** passes through the **Gandhi Sagar WLS** dividing it into two parts. • The western part is in Nimach district and eastern part is in Mandsaur district. • **Mugger crocodiles** are present.

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Ghatigaon WLS	• It is situated near Gwalior. • The sanctuary has a significant population of the **great Indian bustard (CR)**.
Karera WLS	• It is located in the Shivpuri district. • It was established to protect the population of the great Indian bustard in the region. • Major Fauna: The **great Indian bustard** and **blackbuck** (LC).
Ken Gharial WLS	• It near **Panna NP** and the **Khajuraho Group of Monuments in Panna** and Chhatarpur districts. • **Panna National Park** along with **Ken Gharial Wildlife Sanctuary** form a significant part of the catchment area of the **Ken River (a tributary of Yamuna)**. • In the **Ken Gharial Sanctuary gharials (CR fish-eating freshwater crocodiles)** are bred in captivity and then released.
Kheoni WLS	• Located in Dewas district. • It is connected to the proposed **Ratapani WLS** through corridors. • It has a presence of **tigers**, which have apparently migrated from Ratapani.
Narsighgarh WLS	• It is situated in Rajgarh District. • The Parbati River (originates in the Vindhya range) flows along the southeast periphery of the Narsighgarh WLS. • The Parbati River is one of the **Chambal River**'s three main tributaries, along with the **Banas River** and the **Kali Sindh River**.
National Chambal Gharial WLS	• Located on the **Chambal River** near the **tripoint of Rajasthan, MP and Uttar Pradesh** • It is a tri-state protected area for the **Gharial** (CR), the **red-crowned roof turtle** (CR) and the **Ganges river dolphin (EN) —** flagship species (species chosen to represent an environmental cause, such as an ecosystem in need of conservation). • Other Fauna: **muggar crocodile (marsh crocodile – VU)**, **smooth-coated otter (VU), Indian narrow-headed softshell turtle (EN)**, **three-striped roof turtle (CR)**, **Indian soft shell turtle (VU)**, **Indian roofed turtle (LC)**, etc. • The National Chambal Sanctuary is listed as an important bird area.
Noradehi WLS	• It is the largest wildlife sanctuary of Madhya Pradesh. • It is located in the centre of the state covering parts of Sagar, Damoh, and Raisen Districts. • Three-fourths of the sanctuary falls in the basin of the **Yamuna River**, of which the Ken River is a tributary, and one-fourth of the sanctuary falls in the **Narmada basin**. • The forest is spread over the southern area of the **Vindhya Range** of hills in which the **Bandhavgarh National Park** and **Panna National Park** are also located.
Orcha WLS	• The Orchha fort complex and WLS are located in the Tikamgarh district. • They are situated within an island formed by the **Betwa River** (tributary of the Yamuna).
Pachmarhi WLS	• The **Pachmarhi Biosphere Reserve** is situated in the **Satpura Range** of Hoshangabad, Betul, and Chhindwara Districts. • It includes three wildlife conservation units: **1. Bori Sanctuary** **2. Pachmarhi Sanctuary** **3. Satpura National Park**

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Kuno WLS	• Kuno Palpur WLS is located in Sheopur and Morena districts. • It is a **possible site for Cheetah and Asiatic Lion reintroduction in India**.
Panna (Gangau) WLS	• Panna TR = Panna NP + Gangau WLS + Ken Gharial WLS.
Panpatha WLS	• Bandhavgarh TR = Bandhavgarh NP + Panpatha WLS
Phen WLS	• Phen is a buffer zone of Kanha national park. • It lies in south-eastern region of Kanha TR, close to MP and Chhattisgarh state borders.
Ralamandal WLS	• it is a small WLS located on the southern periphery of Indore city.
Ratapani WLS	• It is located in the Raisen district in the Vindhya Range. • It is a **proposed tiger reserve with in-principle approval by NTCA**. • **Madhya Pradesh government has not yet notified it as a tiger reserve**.
Sailana WLS (Bird Sanctuary)	• The Kharmour or Sailana Bird Sanctuary, is situated in Ratlam District. • This sanctuary is home to the 'Kharmour' bird, a very rare species.
Sardarpur WLS	• It is located in the Dhar District. • Sardarpur WLS and Kharmor WLS were established on the recommendations of Salim Ali for the protection of the **Lesser Florican (**EN**)**.
Singhori WLS	• It contiguous with Ratapani WLS in the Vindhyas. • The **Narmada River Basin** separates the **Ratapani WLS** and the **Singhori WLS** (north) from the Satpura TR (south).
Son Gharial WLS	• It is located in Sidhi District. • It was declared a WLS to protect the natural habitat of **Gharial** and **marsh crocodile**.
Veerangna Durgavati WLS	• It is located in the Vindhyas of Damoh district.

37.5.19. Maharashtra

Amba Barwa WLS	• It is located in the Buldana district to the west of Melghat WLS. • **Melghat TR** = **Gugamal NP + Melghat WLS, Narnala WLS & Amba Barwa WLS**.
Andhari WLS	• **Tadoba TR = Tadoba NP + Andhari WLS**
Aner Dam WLS	• It is situated on southwestern range of Satpura range in Dhule district. • It (west) is contiguous with the Yawal WLS (east).
Bhamragarh WLS	• It is located in Chandrapur district in the Vidarbha region. • The river Parlkota (tributary of **Indravati River**) flows through the Bhamragarh WLS. • It is contiguous with the **Indravati TR** (Chhattisgarh).
Bhimashankar WLS	 • Bhimashankar WLS surrounds **Bhimashankar Temple in the Ghat region of the Sahyadris**.

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	• It was created in the Pune District to protect the habitat of the **Indian Giant Squirrel or Malabar giant squirrel (LC) — the state animal of Maharashtra**. • Bhimashankar Temple is popular Jyotirlinga shrine in MH (others are **Trimbakeshwar (Nashik) & Grishneshwar (Aurangabad))**. • **Bhimashankar** is the **source of the river Bhima**, which flows southeast and merges with the **Krishna river** near Raichur.
Chaprala WLS	• It is located in Gadchiroli District. • The **Pranhita River (formed by the confluence of Wardha & Wainganga Rivers)** flows along its western boundary. • Adjacent to the state of Telangana, the sanctuary in Maharashtra serves as a link between the **Tadoba Tiger Reserve** (MH) and the **Indravati Tiger Reserve** (Chhattisgarh).
Deulgaon-Rehekuri WLS	• It is situated in Ahmednagar district. • It was declared a WLS for the conservation of **Blackbuck (LC)**, locally known as 'Kalvit'.
Dhyanganga WLS	• It is situated in the Buldhana district • It about 150 km to the southwest of Melghat Tiger Reserve. • The Dhyanganga River, a minor tributary of the **Purna River**, which itself is a tributary of the **Tapti River**, flows through the Dhyanganga WLS.
New Maldhok Bird (Gangewadi) WLS	• **Gangewadi grassland** area, located on the boundary of Solapur and Osmanabad districts, is now notified and included in the **Great Indian Bustard Sanctuary** in Solapur district.
Gautala-Autramghat WLS	• It lies in the **Satmala and Ajantha Hill ranges** (180 km apart) of the Western Ghats, in Aurangabad District and Jalgaon District. • It is located about 90 km to the west of **Ajanta Caves**.
Ghodazari WLS	• It is located in the Chandrapur district of the Vidarbha region. • It is a tiger corridor that connects **Tadoba-Andhari TR** with Umred Karhandala WLS.
Great Indian Bustard WLS	• Great Indian Bustard Sanctuary (also known as the Jawaharlal Nehru Bustard Sanctuary of Maharashtra) is a WLS for the **great Indian bustard (CR)** at Solapur. • The land is drought-prone and semi-arid.
Isapur WLS	• It is located in the Yavatmal District. • The **River Painganga** (rises in the **Ajantha range; a tributary of Wardha River)** flows through the Isapur WLS.
Jaikwadi WLS (Bird Sanctuary)	• It is located in the Aurangabad and Ahmednagar districts. • It sprawls across the backwaters of **Nath Sagar reservoir (Jaikwadi dam/Nath Sagar dam**). • **Jaikwadi dam/Nath Sagar** dam was constructed over **river Godavari**. • It is a multipurpose project used to irrigate drought-prone **Marathwada Region**.
Kalsubai Harishchandragad WLS	• It is located in the **Sahyadris** (Western Ghats) of Ahmednagar District. • The WLS surrounds the **Kalsubai peak** (1646 m) — the **highest point of Maharashtra**. • It is located ~100 km to the northeast of **Bhimashankar**.
Karnala Fort WLS (Bird Sanctuary)	• It is located between Mumbai and **Lonavala Hill Station** in Raigad District. • **Lonavala** and the adjacent **Khandala** are twin hill stations in the Sahyadris. • The sanctuary is centred on the historic **Karnala Fort**.

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Karanja Sohal Black-buck WLS	• It is located in the Washim district. • It was created to preserve the **blackbuck (LC)** population.
Katepurna WLS	• It is located in the Akola district in the Vidarbha region. • It is renowned for the **four-horned antelope (chausingha – VU)** and **barking deer (Indian muntjac – LC)**.
Koka WLS	• It is situated in the Bhandara district. • It lies between the left bank of **Wainganga River** and **Nagzira WLS**.
Koyana WLS	• It is an Important Bird area located in the Western Ghats of Satara district. • The **Sahyadri TR** is located between Koyna WLS (north) and **Chandoli NP (south)**. • It forms the catchment area for the **Koyna River**, and **Shivsagar reservoir** formed by the **Koyna Dam** (the major portion of the Shivsagar reservoir or Shivajisagar Lake and the Koyna Dam lie in the **Sahyadri TR**).
Lonar WLS	• **Lonar Lake** is a saline alkaline lake (pH value more than 7) located in Buldhana district. • Lonar Lake is a 56,000-year-old crater created by a **meteor impact** during the Pleistocene Epoch (2.58 million to 11,700 years ago). • **It was recently included in the Ramsar List**.
Malvan Marine WLS	• It is located along the coastal zone of the Sindhudurg District. • The core zone includes the **Sindhudurg fort** (built by Chhatrapati Shivaji Maharaj). • Sindhudurg Fort occupies an islet near the coastal town of Malvan.
Mansingdeo WLS	• On the Maharashtra side, the Mansinghdeo WLS acts as a **buffer zone of Pench TR**.
Mayureswar Supe WLS	• It is located in Pune district.
Naigaon Peacock WLS	• It is located in Beed district.
Nandur Madhameshwar WLS (Bird Sanctuary)	• It is located in Nashik District at the confluence of the Godavari and Kadwa Rivers. • It was recently designated as a **Ramsar Site.** • It is **Maharashtra's first Ramsar site**.
Narnala Bird WLS	• It is located in the **Gawilgarh Hills** (Akola district in Vidarbha) along with the **Melghat TR**. • It acts as a gateway of Melghat from the southern side. • Both the Narnala fort and the **Gawilgarh Fort** are located in the **Gawilgarh Hills**
Painganga WLS	• It is located in Yavatmal and Nanded districts. • It is flanked by river Painganga or Penganaga River on the three sides. • **Penganaga River** rises in the **Ajantha range** and is a major tributary of the **Wardha River**.
Phansad WLS	• It is located in Raigad district. • It was created to preserve some of the coastal woodland ecosystem of the Western Ghats.
Radhanagari WLS	• It is located in Kolhapur district. • It lies at the southern end of the Sahyadri hills in the Western Ghats. • It is the first declared wildlife sanctuary in Maharashtra. • **Indian bison or gaur (VU) is the flagship species** of the area.

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Sagareshwar WLS	• It is located 70 km to the east of Chandoli NP in Sangli district (lies outside Western Ghats). • It is a man-made forest.
Sudhagad WLS	• It surrounds the Sudhagad Fort located in the Western Ghats of Raigad District. • It lies between **Lonavla hill station** (north) and **Raigad Fort** (south). • Thanale Buddhist caves (belong to first century B.C.) lie close to Sudhagad Fort.
Tamhini WLS	• It is located along the Mulshi Dam adjacent to the Sudhagad Fort.
Tansa Lake WLS	• It is located between Mumbai and Nashik in Thane District.
Thane Creek Flamingo WLS	• Thane Creek is an inlet with mangroves that isolates Mumbai from the mainland. • It is Maharashtra's second marine sanctuary after Malvan sanctuary.
Tipeshwar WLS	• It is an isolated WLS with tiger presence located in Pandarkawada district. • It is located between Isapur (~150 km west) and **Tadoba TR** (~150 km east) • **Penganga River** flows along the southwestern periphery of the WLS.
Tungareshwar WLS	• The Vasai Creek separates it from Sanjay Gandhi NP (Mumbai).
Umred-Kharngla WLS	• It is located in Bhandara and Nagpur districts. • It is a tiger corridor that connects **Tadoba-Andhari TR** with **Nagzira TR**. • It is bounded by the **Wainganga river** on east
Wan WLS	• It is a south-eastern part of the Melghat TR in the Amravati District.
Yawal WLS	• It is located in the Satpura Range of Jalgaon district. • It lies ~150 km to the west of **Melghat TR**.
Yedsi Ramlin Ghat WLS	• It is located in Osmanabad district.

37.5.20. Manipur

Yangoupokpi Lokchao	• Southeast of **Loktak Lake (Keibul Lamjao NP)** along the Indo-Myanmar border.
Khongjaingamba Ching	• Details not available online.
Jiri Makru	• Located between the **tributaries of the Barak river** near the Assam-Manipur border. • Major Fauna: capped langur and hoolock gibbon.
Kailam	• It is home to a variety of hornbills, including the Great Indian Hornbill. • Major Fauna: hoolock gibbon, barking deer, clouded leopard, etc.
Zeilad	• It is a group of lakes. Wildlife is similar to Kailam WLS.
Bunning	• Located in the Barail Range.
Thinungei Bird	• It is a floodplain. It is the first Bird Sanctuary of Manipur.

37.5.21. Meghalaya

Baghmara Pitcher Plant	• It is located on the banks of Someshwari River that divides the Garo Hills into two parts.

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Narpuh WLS	• It is located in the **Jaintia Hills**.
Nongkhyllem WLS	• Located in Ri Bhoi District.
Siju Bird WLS	• It is located on the banks of Simsang River in the South **Garo Hills** District.

37.5.22. Mizoram

Khawnglung WLS	• It is located in the **Lushai Hills**. • It ~200 km to the southwest of **Murlen NP** and ~200 km to the southeast of **Dampa TR**.
Lengteng WLS	• It is located ~50 km to the north of **Murlen NP in the Lushai Hills**.
Ngengpui WLS	• It is located in the Southern Mizoram in the Mizo Hills.
Tawi WLS	• It is located ~120 km to the southwest of Murlen NP in the **Lushai Hills**.
Thorangtlang WLS	• It is located in the Mizo Hills of the Lunglei district.
Tokalo WLS	• It is located to the south of Ngengpui WLS.

37.5.23. Nagaland

Fakim WLS	• It is located in the **Naga Hills** along the Indo-Burma border.
Puliebadze WLS	• It is located ~100 km to the east of **Intanki (Ntanki) NP in** the northern end of the **Barail Range**.
Rangapahar WLS	• It is located ~80 km to the north of **Intanki NP** in the plains of Dimapur District.

37.5.24. Odisha

Badrama (Ushakothi) WLS	• It is situated in Sambalpur district. • To the west of the Sanctuary lies **Hirakud Dam (Ib river** joins **Mahanadi River** in **Hirakud Reservoir),** and to the east lies **Rengali Reservoir (on Brahmani River)**.
Baisipalli WLS	• It is located to the Satkosia Gorge WLS (part of Satkosia TR). • It is located where the Mahanadi River passes through a gorge in the Eastern Ghats.
Balukhand Konark WLS	• It is located along the Bay of Bengal coast, between the towns of **Puri** and **Konark**. • It includes sandy beaches, coastal dunes, groves of introduced Casuarina plantations. • Major Fauna: blackbuck, spotted deer, etc.
Chandaka Dampara WLS	• It is an **Elephant Sanctuary** located in Khurdha and Cuttack Districts. • It is bound on the north by the **Mahanadi River near Cuttack**. • The **Mahanadi River** separates it from **Kapilash WLS**.
Debrigarh WLS	• It is located in Sambalpur district. • It is bound on the north and east by the **Hirakud Dam**.
Hadgarh WLS	• It is situated just to the south of **Similipal NP** and west of Kuladiha WLS in Keonjhar district. • It lies in the catchment of **Salandi river**, a major tributary of the **river Baitarani**.
Kapilash WLS	• It is situated near **Cuttack** in Dhenkanal district between **Mahanadi** and **Brahmani Rivers**. • It is an elephant corridor.
Karlapat WLS	• It is located in the Easter Ghats of Kalahandi district.

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Khalasuni WLS	• It is located adjacent to Badrama WLS in Sambalpur district.
Kothagarh WLS	• It is an Elephant Reserve situated in Eastern Ghats of Kandhamal district. • It is contiguous with Karlapat WLS and **Satkosia TR**.
Kuldiha WLS	• It is situated in the Balasore district. • It is linked with **Simlipal NP** via small hill ranges.
Lakhari Valley WLS	• It is located in Eastern Ghats of Ganjam District. • The **Rushikulya River** flows through the region.
Nandankanan WLS	• It is a zoological park and botanical garden in Bhubaneswar. • It is located in the environs of the **Chandaka forest** and Kanjia lake. • It is known for the captive breeding of Asiatic lions, tigers and crocodiles.
Satkosia Gorge WLS	• **Saktosia TR = Satkosia Gorge WLS + Baisipalli WLS.**
Sunabeda WLS	• It is a proposed tiger reserve located in the Nuapada district, adjoining Chhattisgarh. • It forms the catchment area of the **Jonk River**. • It is contiguous with the **Udanti-Sitanadi TR of Chhattisgarh**. • Major Fauna: tiger, swamp deer, **wild water buffalo (EN)**, etc.

37.5.25. Puducherry

Oussudu WLS	• Oussudu lake is bird sanctuary that spreads in Puducherry and Tamil Nadu.

37.5.26. Punjab

Abohar WLS	• It is located in the Fazilka district, close to the intersection of Haryana, Rajasthan & Punjab. • Unlike other wildlife sanctuaries that are located over public land, the Abohar WS spreads over the private land inhabited by the **Bishnoi community**. • The **black buck (LC) (State Animal of Punjab)** is considered to be sacred by the Bishnois. • The community also protects the **blue bull** popularly known as the **Nilgai (LC)**.
Bir Aishvan WLS	• It is located in Sangrur District.
Bir Bhadson WLS	• It is located in Patiala District.
Bir Bunerheri WLS	• It is located in Patiala District.
Bir Dosanjh WLS	• It is located in Patiala District.
Bir Gurdialpura WLS	• It is located in Patiala District.
Bir Mehaswala WLS	• It is located in Patiala District.
Bir Motibagh WLS	• It is located in Patiala District.
Harike Lake WLS	• Harike Lake is a large wetland and a **Ramasar site**. • The wetland was formed after constructing the headworks across the Sutlej river. • The headworks is located downstream of the **confluence of the Beas and Sutlej rivers**.
Jhajjar Bacholi WLS	• It is located in Rupnagar district, near Punjab-Himachal border.
Kathlaur Kushlian WLS	• It lies on the left bank of the Ravi River in the Gurdaspur district. •

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Nangal WLS	• It is a **Ramsar Site** located in the Shiwalik foothills. • It occupies a human-made reservoir constructed as part of the **Bhakra-Nangal** Project. • Indian and Chinese Prime Ministers formalized the "Five Principles of Peaceful Coexistence" there in 1954.
Takhni-Rehampur WLS	• It is part of the Shivalik range in the Hoshiarpur district.

37.5.27. Rajasthan

Bandh Baratha WLS	• It surrounds Baretha Dam in the Bharatpur district.
Bassi WLS	• It is located about 120 km to the west of Mukundra TR, in Chittorgarh district.
Bhensrodgarh WLS	• It is located near the **Rana Pratap Sagar Dam** (on **Chambal River**).
Darrah WLS	• Mukundara Hills (Darrah) NP is a national park consisting of three wildlife sanctuaries: Darrah Wildlife Sanctuary, Chambal Wildlife Sanctuary, and Jawahar Sagar Wildlife Sanctuary.
Jaisamand WLS	• It is located in the Udaipur District around Dhebar Lake (Jaisamand Lake). • Dhebar lake is one of the largest artificial lakes in India (**Govind Ballabh Pant Sagar on Rihand River – a tributary of Son River –** is India's largest artificial lake.)
Jamwa Ramgarh WLS	• Ramgarh Lake is a human-made lake near Jaipur. • About 60 km to the north-east lies the **Sariska TR**.
Jawahar Sagar WLS	• It is located near the **Jawahar Sagar Dam (over the Chambal River)** in Kota District. • Jawahar Sagar Dam is the third dam in the series of Chambal Valley Projects. • It is located 29 km upstream of Kota Barrage and 26 km downstream of **Rana Pratap Sagar**.
Kailadevi WLS	• It is the northern extension of the **Ranthambore NP**. • It is located in the Karauli district. • It is bounded on the west by the river **Banas** and on the south by the river **Chambal**.
Kesarbagh WLS	• It is located in Dholpur District.
Kumbhalgarh WLS	• It extends across the Aravalli Range in Rajsamand District.
Mount Abu WLS	• It is located in the **Aravalli range**. • In altitude, it ranges from 300 to 1,722 m at **Guru Shikhar** (**highest peak in Rajasthan**).
Nahargarh WLS	• It is located in the vicinity of **Nahargarh Fort**, located on the outskirts of **Jaipur**.
National Chambal WLS	• It is located on the **Chambal River** near the tripoint of Rajasthan, MP and Uttar Pradesh.
Phulwari Ki Nal WLS	• It is located in Udaipur District, in the southern Aravalli Hills bordering the state of Gujarat.
Ramgarh Vishdhari WLS	• It is located in Bundi district. • It was recently upgraded to **Tiger Reserve.**
Ramsagar WLS	• It is located in Dholpur district.
Sajjangarh WLS	• It is located in Udaipur District in the southern Aravalli Hills.
Sawaimadhopur WLS	• It is a part of Ranthambore TR.

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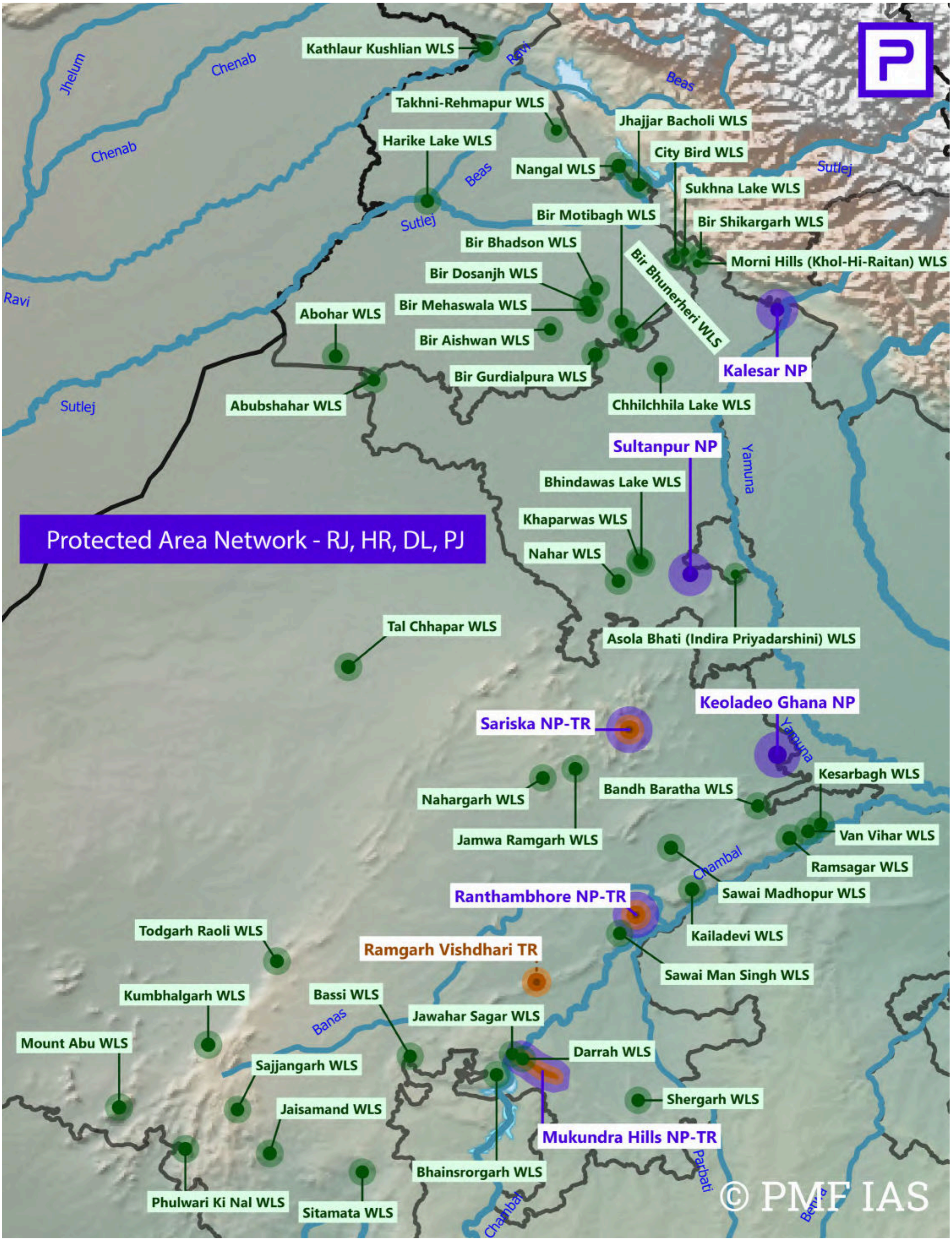

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Sawai Man Singh WLS	• It is a part of Ranthambore TR.
Shergarh WLS	• It is located about 100 km to the east of Mukundara Hills NP, in Baran district.
Sitamata WLS	• It is situated in Pratapgarh and Chittaurgarh districts. • The average elevation ranges between 280 and 600 metres • It was **once considered for the reintroduction of the Asiatic lion**.
Tal Chhapar WLS	• It is located in the Churu district. • It is known for **blackbucks** (LC).
Todgarh Raoli WLS	• It is spread along the Aravallis of Ajmer, Pali and Rajsamand districts.
Van Vihar WLS	• Van Vihar WLS and Ramsagar WLS are located in Dholpur district.

37.5.28. Sikkim

Barsey Rhododendron WLS	• It is located in the **Singalila Range** in western Sikkim. • It is contiguous with the **Singlalila NP of West Bengal**. • It borders Nepal to the west and the state of West Bengal to the south.
Fambong Lho WLS	• It is located near Gangtok in East Sikkim district. • It is contiguous with the Khangchendzonga NP.
Kitam Bird WLS	• It is located close to the Sikkim-WB border, near Darjeeling.
Kyongnosla Alpine WLS	• It is located about 30 km east of Gangtok.
Maenam WLS	• It is located in the South Sikkim district.
Pangolakha WLS	• It is located in East Sikkim district. • It is linked to the forests of **Neora Valley NP** of West Bengal.
Shingba Rhododendron WLS	• It is located in North Sikkim district.

37.5.29. Tamil Nadu

Cauvery North WLS	• It is located in the Dharmapuri and Krishnagiri districts of Tamil Nadu. • Sanctuary is named as it is located north of Cauvery river. • Sanctuary comes under the **Melagiri Hill ranges.** • It is a wildlife corridor where it forms the vital link to the **Male Mahadeshwara Hills (Karnataka), Biligiri Ranganathaswamy Hills (BR Hills in Karnataka), Sathyamangalam WLS (TN)** and **Nilgiri Biosphere Reserve**.
Chitrangudi Bird WLS	• It is located in Ramanathapuram District. • It is adjacent to Kanjirankulam Bird Sanctuary.
Gangaikondam Spotted Dear WLS	• It is located in Tirunelveli district. • It is a major habitat of **spotted deer (Chital –** LC**)** outside the Western Ghats.
Kanjirankulam Bird WLS	• It is located in Ramanathapuram District.
Kanyakumari WLS	• It is located in Kanyakumari district. The area is a tiger habitat. • It is about 50 km to the south of Kalakad-Mundanthurai TR.
Karaivetti Bird WLS	• It is located close to the left bank of Kollidam River, in Ariyalur District. • The **Kollidam (Coleroon) River** is the **northern distributary of the Kaveri River**.

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	• It flows through the delta of **Thanjavur**.
Karikilli Birds WLS	• It is located in Kancheepuram District. • It is located close to the confluence of **Palar** and **Cheyyar Rivers**, ~80 km south of Chennai.
Kodaikanal WLS	• It covers forest areas of **Palani Hills** of Dindigul and Theni districts.
Koonthankulam-Kadankulam WLS	• It is located in Tirunelveli district. • It is an Important Bird Area.
Megamalai WLS	• Meghamalai mountain range is located in the Western Ghats in Theni district. • It acts as a **buffer to the Periyar TR** and **Srivilliputhur Grizzled Squirrel WLS**.
Melaselvanoor-Keelaselvanoor WLS	• It is a Bird Sanctuary located in Ramanathapuram district.
Nellai WLS	• It is located in Tirunelveli district.
Oussudu Lake Bird Sanctuary	• It spreads in Puducherry and Tamil Nadu.
Point Calimere WLS	• It is located at the south-eastern tip of Nagapattinam District. • It was created for conservation of **blackbuck** (one of the four antelope species in India — Chinkara, Chausingha and Nilgai being the other three).
Pulicat Lake Bird WLS	• It is located in Nellore district of AP and Thiruvallur District of Tamil Nadu.
Sakkarakottai Bird Sanctuary	• It is located in Ramanathapuram district.
Srivilliputhur Grizzled Squirrel WLS	• It was established to protect the **grizzled giant squirrel (NT).** • **Srivilliputhur-Megamalai TR = Megamalai WLS + Srivilliputhur WLS**. • It is contiguous to **Periyar TR (Kerala)** on the south western side and the Megamalai WLS on the north western side.
Theerthangal Bird Sanctuary	• It is located in Ramanathapuram district.
Udayamarthandapuram Lake WLS	• It is located in Tiruvarur District.
Vaduvoor Birds WLS	• It is located in Vaduvoor lake, near Thanjavur, Thiruvarur District.
Vedanthangal Lake Birds WLS	• It is located just to the south of Palar River in Chengalpattu District.
Vellanadu Blackbuck WLS	• It is located in Thoothukudi district. • It is created for the protection of **blackbuck** (LC) antelope.
Vellode Birds WLS	• It is located near Vellore in the Erode District.
Vettangudi Birds WLS	• It is located in Sivaganga District.

37.5.30. Telangana

Eturnagaram WLS	• It is a part of the **Dandakaranya** forests of Mulugu district. • **Godavari river** passes through the sanctuary. • The forests are inhabited by the **Koya Tribes** since centauries. • The biennial **Sammakka Saralamma Jatara (Medaram Jatara)** is held in the sanctuary.

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Kinnersani WLS	• It is located close to the temple town of Bhadrachalam in Bhadradri Kothagudem district. • The sanctuary surrounds Kinnerasani Reservoir on Kinnerasani River. • Kinnersani WLS (south) is contiguous with the Eturnagaram WLS (east).
Lanja Madugu Siwaram WLS	• It is situated on the right bank of the **Godavari River** in Mancherial district. • It is home to marsh crocodiles (mugger) from the river Godavari.
Manjeera Crocodile WLS	• Manjeera WLS and Manjeera (Manjira) reservoir are located in Sangareddy district. • The **Manjara** is a tributary of the **river Godavari**. • Manjeera reservoir is a man-made reservoir that provides drinking water to Hyderabad. • The sanctuary is a riverine habitat supporting **mugger crocodile (VU)** & fresh water turtles.
Pakhal WLS	• Pakhal lake is a manmade lake situated near Warangal.
Pocharam WLS	• It is located in the districts of Nizamabad and Medak. • It is named after the Pocharam lake.
Pranahita WLS	• It is located on the bank of **Pranahita River** in Mancherial district. • It is famous for **Blackbuck (LC)**. • **Pranahita River** carries combined waters of the **Penganga, Wardha** & **Wainganga** Rivers. • The river empties itself into the **Godavari River** at **Kaleswaram (Kaleshwaram lift irrigation** project by Telangana).

37.5.31. Tripura

Gumti WLS	• It is located in South Tripura region.
Rowa WLS	• It is situated in North Tripura district.
Sepahijala WLS	• It is located about 30 km to the south of Agartala. • **Clouded Leopard NP** is located in Sepahijala WLS. • It is famous for its **clouded leopard (VU)** enclosures.
Trishna WLS	• It is situated in South Tripura District. • Bison (Rajbari) NP is located in the Trishna WLS. • Major Fauna**: Indian Gaur (Bison – VU), Hoolock Gibbon (EN), Golden Langur (EN), Capped Langur (VU),** etc.

37.5.32. Uttar Pradesh

Bakhira WLS	• It is a natural flood plain wetland located in Sant Kabir Nagar district. • The Rapti river flows between Bakhira WLS (west) from Gorakhpur (east). • It provides a wintering ground for a number of migratory birds.
Chandraprabha WLS	• It is situated in Chandauli district, about 70 kilometres south of Varanasi. • It is spread over the hillocks on the north slope of the **Kaimur Range** between the Ganges and Son rivers.
Dr. Bhimrao Ambedkar Bird WLS	• It is located in the Pratapgarh district.
Hastinapur WLS	• It covers Meerut, Muzzafarnagar, Bijnor and Meerut districts.

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	• It lies on the western bank of the **Ganges River**. • Major Fauna: **swamp deer (VU), smooth-coated otter (VU), Ganges river dolphin (EN), gharials (CR)**, etc.
Jai Prakash Narayan (Surhatal) Bird WLS	• Jai Prakash Narayan (Surhatal) Bird WLS or Surha Taal wetland is located in Ballia district near the confluence of **Ghaghara** and **Ganges Rivers**.
Kaimur WLS	• It is located in Sonbhadra and Mirzapur districts. • It is contiguous with the Chandraprabha WLS of UP and Kaimur WLS of Bihar. • The extends along the **Kaimur Range**, extending to the **Son River** at its eastern end, and to the border of Madhya Pradesh at its western end. • It is an important tiger and elephant corridor.
Katerniaghat WLS	• It is a located in the Upper Gangetic terai plain of Bahraich district. • It provides connectivity between the tiger habitats of Dudhwa and Bardia National Park in Nepal. • The **Ghaghara River** separates Dudhwa NP (west) from Katerniaghat WLS (east). • **Dudhwa TR = Katerniaghat WLS + Kishanpur WLS + Dudhwa NP**. • One of the best places in the world for seeing the gharial in its natural habitat is the **Gir-wa River**, where it is found sympatric with the mugger. • Major fauna: tigers, **gharials (CR)**, **mugger crocodiles or marsh crocodile (VU)**, etc.
Kishanpur WLS	• It is contiguous with the **Pilibhit TR**. • The **Sarda River (known as Kali River before it reaches the plains — it flows along the Indo-Nepal Border**) separates Kishanpur WLS from the Dudhwa NP. • Major Fauna: **swamp deer (VU), Bengal florican (CR)**, **Lesser Florican (EN)**, etc.
Lakh Bahosi Bird WLS	• It is in located in Kannauj district.
Mahavir Swami WLS	• It is located in Lalitpur district, along the MP-UP border. • It lies on the eastern bank of **Betwa River (a tributary of Yamuna)** near **Rajghat reser-voir**.
National Chambal Gharial WLS	• Located on the **Chambal River** near the tripoint of Rajasthan, MP and Uttar Pradesh.
Nawabganj Bird WLS	• Also known as Shahid Chandra Shekhar Azad Bird Sanctuary. • It is located in Unnao district on the Kanpur-Lucknow highway, near Lucknow. • It was declared a **Ramsar Site** in January 2020.
Okhala Bird WLS	• It is located at the Okhla barrage over **Yamuna River** in Noida, Gautam Buddh Nagar district, on the Delhi-Uttar Pradesh state border. • This wetland was formed by the creation of Okhla Barrage.
Parvati Aranga WLS	• It is situated in the Gonda District. • It was declared a **Ramsar Site** in January 2020. • It is an **ox-bow lake** formed by the **Ghaghara River** near Faizabad.
Patna WLS	• It is located about 70 km the north-east of Agra in Etah district.
Ranipur WLS	• It is located in Chitrakoot district.
Saman Bird WLS	• It is a seasonal oxbow lake on the Ganges floodplain in the Mainpuri district. • It has been designated as a protected **Ramsar site** since 2019.
Samaspur Bird WLS	• It is a perennial lowland marsh located in Rae Bareli district.

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	• It lies at about 122 km from Lucknow on Lucknow-Varanasi highway. • It has been designated as a protected **Ramsar site** since 2019.
Sandi Birds WLS	• It is a freshwater marsh in the Hardoi district. • It is designation as an **Important Bird Area** by BirdLife International. • It has been designated as a protected **Ramsar site** since 2019.
Shekha Bird WLS	• It located near Aligarh. • It is a perennial lake that came into existence after the formation of the Upper Ganges Canal.
Sohagibarwa WLS	• It is located on the west bank of the **Gandak River** in the Maharajganj district.
Sohelwa WLS	• It is located along the Shivalik hills of Balrampur, Gonda and Sravasti districts.
Sur Sarovar Bird WLS	• It is located on the right bank of Yamuna River near Agra.
Turtle WLS	• It is located in Varanasi district.
Vijai Sagar WLS	• Vijai Sagar Sanctuary is located in Mahoba District.

37.5.33. Uttarakhand

Askot WLS	• It is located in Pithoragarh district. • Its altitude ranges from 600 m to 6,905 m. • **This sanctuary has been set up for conserving the musk deer (EN).**
Binsar WLS	• It is located in Almora district. • Its altitude varies from 900 to 2500 metres.
Kedarnath WLS	• This sanctuary has been set up for conserving the **musk deer (EN)**. • It stretches from **Gaurikund** to **Kedarnath mountain**. • The **Mandakini river** flows through the Kedarnath WLS. • Mandakini originates from the **Chorabari Glacier** near Kedarnath. • Mandakini is fed by **Vasukiganga River** at **Sonprayag**. • Mandakini joins **Alaknanda River** at **Rudraprayag**. • Alaknanda joins **Bhagirathi River** at **Devaprayag** to form the **Ganges River**.
Mussoorie WLS	• Mussoorie or Benog Wildlife Sanctuary is located close to **Rajaji TR**.
Nandhaur WLS	• The **Jim Corbett TR** lies between **Rajaji TR (west)** and **Nandhaur WLS (east)**. • Nandhaur is primarily a sal forest and is a part of the **Shivalik Elephant Reserve**.
Sonanadi WLS	• Sonanadi WLS (east) is contiguous with the **Jim Corbett TR** (west).

Q. Which of the following are the most likely places to find the musk deer in its natural habitat?

1) Askot Wildlife Sanctuary
2) Gangotri National Park
3) Kishanpur Wildlife Sanctuary
4) Manas National Park

Select the correct answer using the code given below

a) 1 and 2 only
b) 2 and 3 only
c) 3 and 4 only
d) 1 and 4 only

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Answer: Musk Deer's natural habitat lies in the forests of the Middle Himalayas. a) 1 & 2 only

37.5.34. West Bengal

Ballavpur WLS	• It is located in Birbhum District.
Bethuadahari WLS	• It is located in Nadia District.
Bibhuti Bhusan WLS	• It is located in North 24 Parganas district.
Chapramari WLS	• Chapramari WLS (north) is contiguous with **Gorumara NP** (south). • They lie between **Teesta** (west) and **Jaldhaka** (east) Rivers.
Chintamani Kar Bird WLS	• It is situated at south Kolkata.
Haliday Island WLS	• The island is a part of the **Sundarbans Biosphere Reserve**.
Jorepokhri Salamander WLS	• It is situated in Darjeeling District.
Lothian Island WLS	• It an island located in South 24 Parganas district.
Mahananda WLS	• It is located on the foothills of the Himalayas in the Darjeeling district, between the **Teesta** and Mahananda rivers (a small tributary of Ganga that flows in eastern Bihar between **Kosi** (west) and **Teesta** (east) Rivers).
Pakhi Bitan Bird WLS	• It is located in the foreshore of **Teesta Barrage** in Jalpaiguri district.
Raiganj Bird WLS	• It is situated near Raiganj in Uttar Dinajpur district.
Ramnabagan WLS	• It is located in Bardhaman city (situated on the left bank of the **Damodar River**) in Purba Bardhaman district.
Sajnakhali WLS	• It is located in the northern part of the Sundarbans delta in South 24 Parganas district.
Senchal WLS	• It is located in the Darjeeling District. • Senchal WLS (east) is contiguous with the **Singalila NP** (west).
West Sunderban WLS	• It is part of the larger Sundarbans region.

37.6. Biosphere Reserves

- Biosphere reserves are **sites established by countries** and **recognized under UNESCO's Man and the Biosphere (MAB) Programme** to **promote sustainable development based on local community efforts** and **sound science**.

37.6.1. UNESCO's Man and the Biosphere (MAB) Programme

- UNESCO's Man and the Biosphere (MAB) Programme was initiated by UNESCO in 1971.
- The purpose of the formation of the biosphere reserve is to **conserve in situ all forms of life**.
- MAB aims to establish a **scientific basis** for **enhancing the relationship between people and their environments**.
- **Biosphere reserves are nominated by national governments** and **remain under the sovereign jurisdiction of the states**.
- Their status is **internationally recognized by UNESCO's MAB**.
- **World Network of Biosphere Reserves** currently counts 701 sites (in 124 countries), including 21 transboundary sites.
  1. 79 sites in 29 countries in Africa
  2. 33 sites in 12 countries in the Arab States

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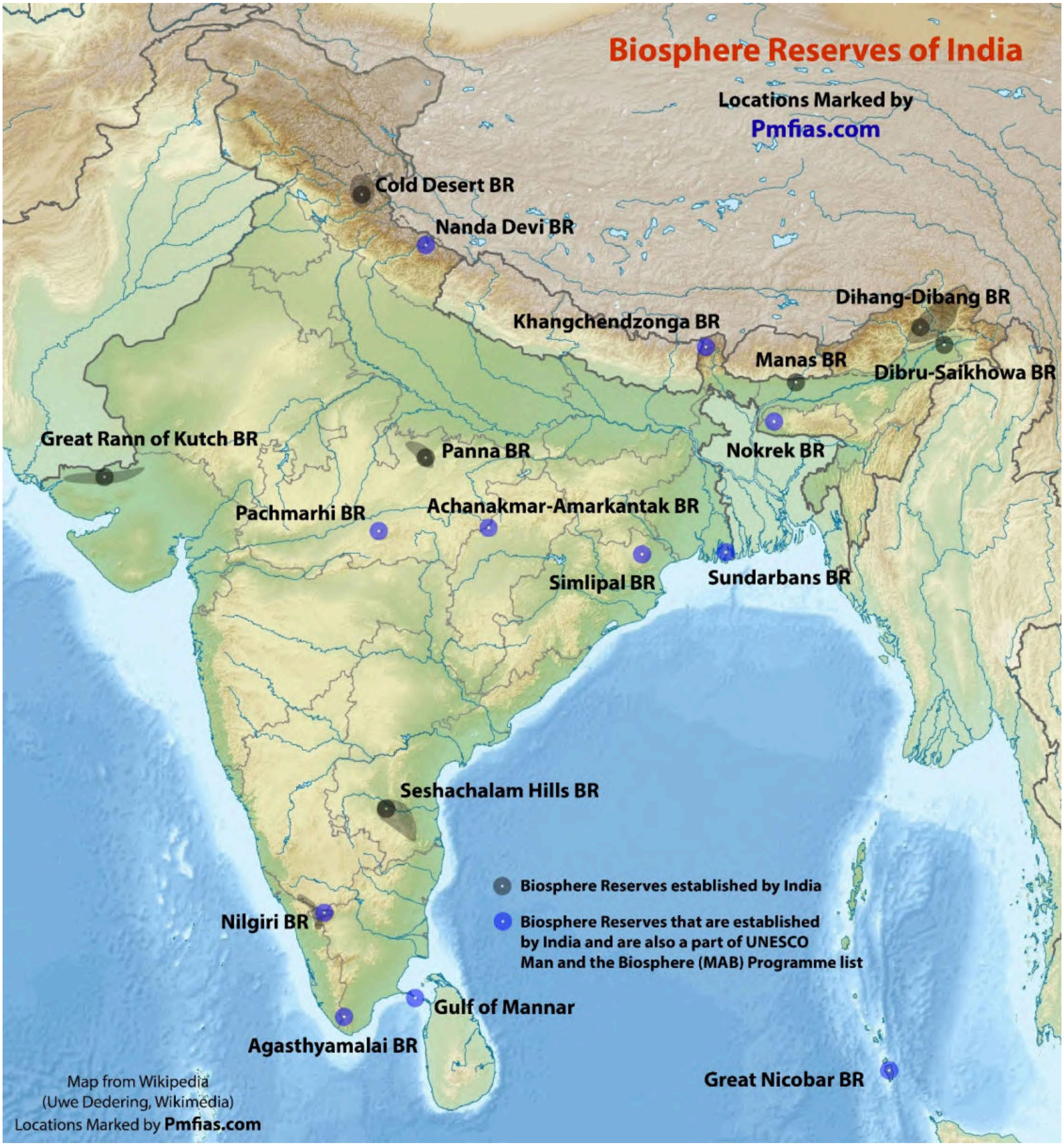
3. 157 sites in 24 countries in Asia and the Pacific **(Second Highest Number of BRs)**
4. 302 sites in 38 countries in Europe and North America **(Highest Number of BRs)**
5. 130 sites in 21 countries in Latin America and the Caribbean.

37.6.2. Biosphere Reserves of India

- Presently, there are **18 notified biosphere reserves in India** (**11 of them are recognized by UNESCO's MAB**).



S.No.	Year	Name	State	Area (km²)

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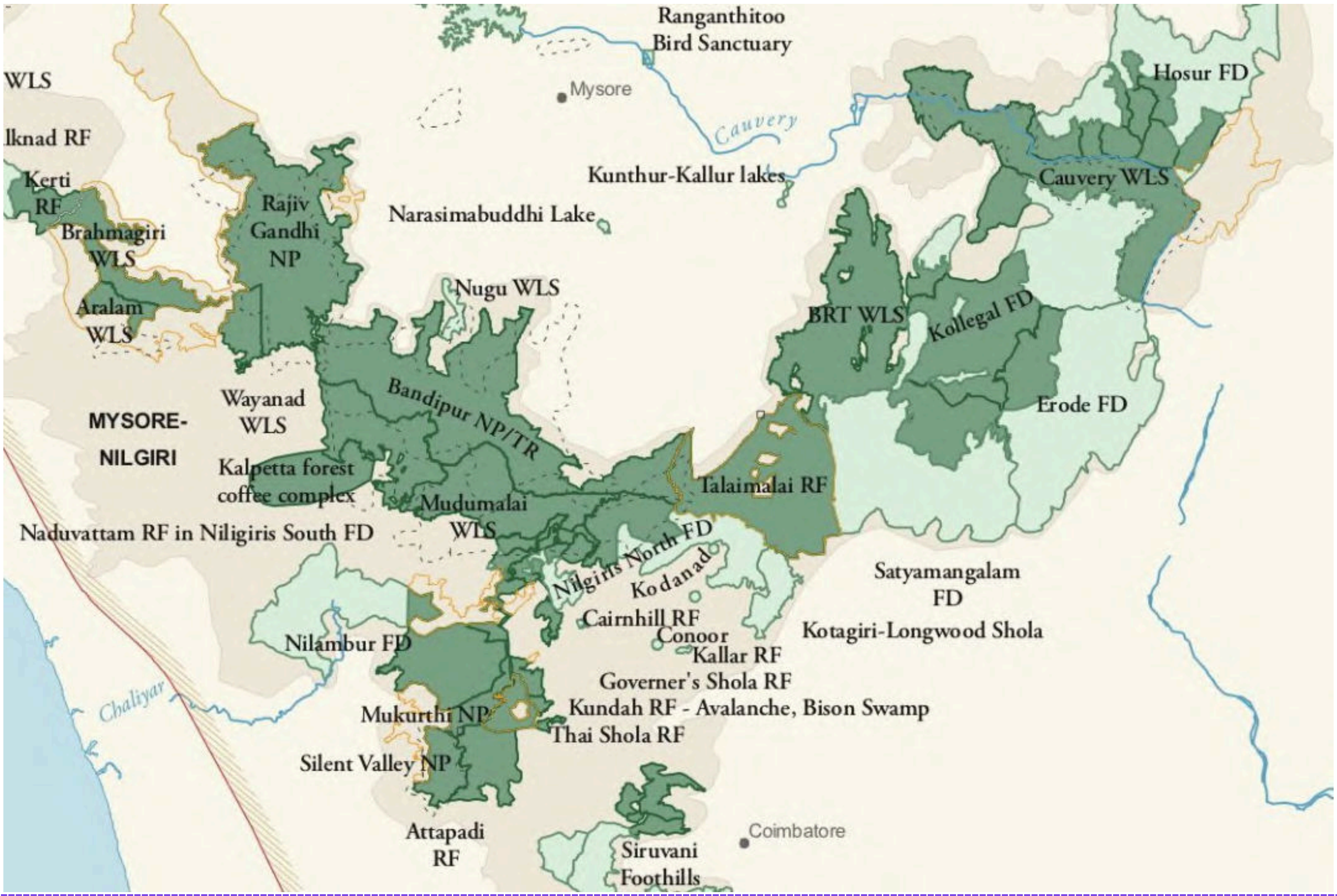
1	1986	**Nilgiri Biosphere Reserve**	TN (2537), Kerala (1455), Karnataka (1527)	5520
2	1988	**Nanda Devi Biosphere Reserve**	Uttarakhand	5860
4	1988	**Nokrek Biosphere Reserve**	Meghalaya	820
3	1989	**Gulf of Mannar Biosphere Reserve**	Tamil Nadu	10500
5	1989	**Sundarbans Biosphere Reserve**	West Bengal	9630
6	1989	**Manas Biosphere Reserve**	Assam	2837
7	1989	**Great Nicobar Biosphere Reserve**	Andaman and Nicobar Islands	885
8	1994	**Simlipal Biosphere Reserve**	Odisha	4374
9	1997	**Dibru-Saikhowa Biosphere Reserve**	Assam	765
10	1998	**Dihang-Dibang Biosphere Reserve**	Arunachal Pradesh	5112
11	1999	**Pachmarhi Biosphere Reserve**	Madhya Pradesh	4982
12	2000	**Khangchendzonga Biosphere Reserve**	Sikkim	2620
13	2001	**Agasthyamalai Biosphere Reserve**	Kerala, Tamil Nadu	3500
14	2005	**Achanakmar-Amarkantak BR**	Madhya Pradesh, Chhattisgarh	3835
15	2008	**Great Rann of Kutch BR**	Gujarat	12454
16	2009	**Cold Desert Biosphere Reserve**	Himachal Pradesh	7770
17	2010	**Seshachalam Hills Biosphere Reserve**	Andhra Pradesh	4755
18	2011	**Panna Biosphere Reserve**	Madhya Pradesh	543
Biosphere Reservs Established by India | Biosphere Reservs Established by India and Recognized by UNESCO MAB				

Nilgiri Biosphere Reserve

- **Nilgiris** (**blue mountain)** got their name from the purplish blue flowers of **Neelakurinji** (blossoms once in 12 years).
- The **Nilgiri Sub-Cluster (UNESCO World Heritage Site)** includes the **Mudumalai, Mukurthi, Nagarhole, Bandipur and Silent Valley national parks**, as well as the **Aralam, Wayanad** and **Sathyamangalam wildlife sanctuaries**.



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- Vegetation: tropical evergreen forests (western side of Western Ghats), montane sholas and grasslands (at high altitudes), semi-evergreen forests, moist deciduous forests, dry deciduous forests, and thorn forests.
- Major Fauna: **Lion Tailed Macaque (EN), Nilgiri Tahr (EN), Malabar Giant Squirrel (LC), Nilgiri Langur (VU)**, etc.

Nanda Devi Biosphere Reserve

- **Nanda Devi Biosphere Reserve = Nanda Devi NP + Valley of Flowers NP**.
- Major Fauna: **Snow Leopard (VU), Musk Deer (EN), Bharal Or Blue Sheep (LC)**, etc.

Nokrek Biosphere Reserve

- **Nokrek (1,412 m) is the highest peak of the Garo hills**.
- Vegetation: Evergreen and semi-evergreen deciduous forests.
- Key Fauna: **Red Panda (EN), Hoolock Gibbons (EN), Red Giant Flying Squirrel (LC)**, etc.

Gulf of Mannar Biosphere Reserve

- It lies between the west coast of Sri Lanka and the south-eastern tip of India, in the **Coromandel Coast** region.
- The chain of low islands and reefs known as **Ramsethu (Adam's Bridge)**, which includes **Mannar Island**, separates the **Gulf of Mannar** from **Palk Bay**, which lies to the north between Sri Lanka and India.
- The biosphere reserve comprises islands with estuaries, seagrasses, coral reefs, salt marshes and mangroves.
- Major Fauna: **Dugong (VU), Olive Ridley turtles (VU)**, etc.

Sundarbans Biosphere Reserve

- It is located in the vast Delta of the Ganges, south of Kolkata and bordering Bangladesh in the east.
- **Sundarbans Biosphere Reserve = Sundarbans NP + Sajnekhali WLS + Lothian WLS + Haliday WLS**.
- It provides habitat for the threatened **Royal Bengal Tiger (EN)**.

Manas Biosphere Reserve

- **Manas Biosphere Reserve = Manas National Park**.
- It is contiguous with the Royal Manas National Park in Bhutan.
- Rare and endemic wildlife: **Assam Roofed Turtle (EN), Hispid Hare (EN), Golden Langur (EN) & Pygmy Hog (EN)**.
- Manas is famous for its population of the **Wild Water Buffalo (EN)**.
- The grassland biomes: **Pygmy Hog, Rhinoceros (re-introduced in 2007)**, elephants, **Bengal florican (CR)** etc.

Great Nicobar Biosphere Reserve

- **Great Nicobar Biosphere Reserve = Campbell Bay NP + Galathea National Park**.
- Vegetation: tropical wet evergreen forests.
- Major Fauna: **Dugong (VU), Saltwater Crocodile (LC)**, etc.

Similipal Biosphere Reserve

- It includes **Mayurbhanj Elephant Reserve (Similipal TR + Hadgarh WLS + Kuldiha WLS)**.
- Major tribes: Erenga, Kharias, Mankirdias, Ho, Gonda and Munda.
- Major Fauna: **Royal Bengal Tigers, Wild Elephants (EN), Gaurs (VU – Indian Bison), Chausingha (VU)**.

Pachmarhi Biosphere Reserve

- **Pachmarhi Biosphere Reserve (Satpura NP + Bori WLS + Pachmarhi WLS)** lies in the centre of the **Satpura Range**.
- The highest peak is the Dhoopgarh (1,352 m).

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- **Gonds** are the major tribal group.
- Major Fauna: **Tiger, Gaur, Indian Giant Flying Squirrels (LC)**, etc.

Khangchendzonga Biosphere Reserve

- The biosphere reserve is a transboundary bio-diversity hotspot conservation area.
- It includes the third **highest mountain peak** in the world, **Kanchenjunga (8,586 m)**.
- It is one of the highest ecosystems in the world, **reaching elevations of 1,220 m to 8,586 m above sea level**, the number of biosphere reserves from the country included in World Network of Biosphere Reserves has increased to 11.
- The **Khangchendzonga NP**, which comprises the core area of the KBR, was inscribed as **India's first "Mixed World Heritage Site"**.
- Major Fauna: **Red Panda (EN), Snow Leopard (VU), Musk Deer (EN), Great Tibetan Sheep (Argali – NT),** etc.

Dibru-Saikhowa Biosphere Reserve

- Dibru-Saikhowa Biosphere Reserve = **Dibru-Saikhowa National Park**.
- Major Fauna: **Bengal Tiger, Clouded Leopard (VU), Gangetic Dolphin (EN)**, etc.

Dihang-Dibang Biosphere Reserve

- The **Mouling NP** and the **Dibang WLS** are located fully or partly within this biosphere reserve.
- The terrain is rugged, with an altitudinal range of 750 to 3000 m at the highest point, the Mouling Peak.
- Major Fauna: **Takin (VU)**, **Red Panda (EN)**.

Agasthyamala Biosphere Reserve

- **Agasthyamala BR = Shendurney WLS + Peppara WLS + Neyyar WLS + Kalakad Mundanthurai TR**.
- The reserve is home to Kani tribes from both Tamil Nadu and Kerala.
- Major Fauna: **Nilgiri Tahr (EN)**

Q. Which one of the following are Agasthyamala biosphere reserve?

a) Neyyar, Peppara and Shendurney wildlife sanctuaries and Kalakad Mundanthurai Tiger Reserve
b) Mudumalai Sathayamangalam and Wayanad wildlife sanctuaries and Silent Valley National Park
c) Kaundinya Gundla Bhrameshwaram and Papikonda wildlife sanctuaries and Mukurthi National Park
d) Kawal and Shree Venkateshwara wildlife sanctuaries; and Nagarjunasagar-Srisailam tiger reserve

Achanakmar-Amarkantak Biosphere Reserve

- It extends across the states of **Madhya Pradesh** and **Chhattisgarh**.
- **Maikal hills** together with eastern Vindhyas and Satpuras lie within the reserve.
- Major Fauna: **Four Horned Antelope (Chausingha (VU)), Indian Wild Dog (VU)**, etc.
- Vegetation: moist deciduous and dry deciduous forests.

Great Rann of Kutch Biosphere Reserve

- The Great Rann of Kutch is a **salt marsh in the Thar Desert**.
- Great Rann of Kutch BR = **Kachchh Desert Sanctuary (in Great Rann of Kutch) + Wild Ass Sanctuary (in Little Rann of Kutch), Narayan Sarovar Sanctuary + Kutch Bustard Sanctuary + Banni Grasslands Reserve**.
- Major Fauna: **Great Indian Bustard (CR), Indian Wild Ass (NT)**, etc.

Cold Desert Biosphere Reserve

- It includes **Pin Valley National Park, Chandratal, Sarchu and Kibber Wildlife Sanctuaries**.

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- Major Fauna: **Snow Leopard (VU), Himalayan Ibex (also referred to as Siberian Ibex – LC)**.

Seshachalam Hills Biosphere Reserve

- The **Seshachalam Hills** are part of the **Eastern Ghats (south of Panna River) in southern Andhra Pradesh**.
- **Tirupati**, a major Hindu pilgrimage town and Srivenkateshwara NP are located in these ranges.
- Major Flora: rare and endemic plant species like **Red Sanders (NT)** are of great economic importance.
- Major Reptilian Fauna: **Golden Gecko (LC – Endemic To Tirumala Hills)**.

Panna Biosphere Reserve

- Panna Biosphere Reserve = **Panna TR.**
- Major Fauna**: Tiger (EN), Chital (LC), Chinkara (LC), Sambar (VU)**.

37.6.3. Salient Flora/Fauna of the Biosphere Reserves of India

Name	Key fauna
Nilgiri BR	Lion Tailed Macaque (EN), Nilgiri Tahr (EN), Malabar Giant Squirrel (LC), Nilgiri Langur (VU)
Nanda Devi BR	Snow Leopard (VU), Musk Deer (EN), Bharal Or Blue Sheep (LC)
Gulf of Mannar	Dugong (VU), Olive Ridley turtles (VU)
Nokrek	Red Panda (EN), Hoolock Gibbons (EN), Red Giant Flying Squirrel (LC)
Sundarbans	Royal Bengal Tiger (EN)
Manas	Assam Roofed Turtle (EN), Hispid Hare (EN), Golden Langur (EN), Pygmy Hog (EN), Wild Water Buffalo (EN), Bengal florican (CR)
Simlipal	Royal Bengal Tigers, Wild Elephants (EN), Gaurs (VU – Indian Bison), Chausingha (VU)
Dihang-Dibang	Takin (VU), Red Panda (EN)
Pachmarhi BR	Tiger, Gaur, Indian Giant Flying Squirrels (LC)
Achanakmar-Amarkantak BR	Four Horned Antelope (Chausingha (VU)), Indian Wild Dog (VU)
Great Rann of Kutch	Great Indian Bustard (CR), Indian Wild Ass (NT)
Cold Desert	Snow Leopard (VU), Himalayan Ibex (also referred to as Siberian Ibex – LC)
Khangchendzonga	Red Panda (EN), Snow Leopard (VU), Musk Deer (EN), Great Tibetan Sheep (Argali – NT)
Agasthyamalai BR	Nilgiri Tahr (EN)
Great Nicobar BR	Dugong (VU), Saltwater Crocodile (LC)
Dibru-Saikhowa	Bengal Tiger, Clouded Leopard (VU), Gangetic Dolphin (EN)
Seshachalam Hills	Red Sanders (NT), Golden Gecko (LC – Endemic To Tirumala Hills)
Panna	Tiger (EN), Chital (LC), Chinkara (LC), Sambar (VU)

37.6.4. Natural World Heritage Sites in India (December 2020)

	Name of WH Site	Location	Notified in	Area (km²)
1	**Great Himalayan National Park Conservation Area**	Himachal Pradesh	2014	905
2	**Western Ghats**	Ghats of Maharashtra to Kerala	2012	7953
3	**Nanda Devi and Valley of Flowers National Parks**	Uttarakhand	1988	717
4	**Sundarbans National Park**	West Bengal	1987	1330
5	**Kaziranga National Park**	Assam	1985	430
6	**Keoladeo National Park**	Rajasthan	1985	28.7
7	**Manas Wildlife Sanctuary**	Assam	1985	391

- **Khangchendzonga National Park** is the first "**Mixed Heritage (Cultural + Natural Heritage Site)**" site of India.

37.7. Elephant Reserves of India

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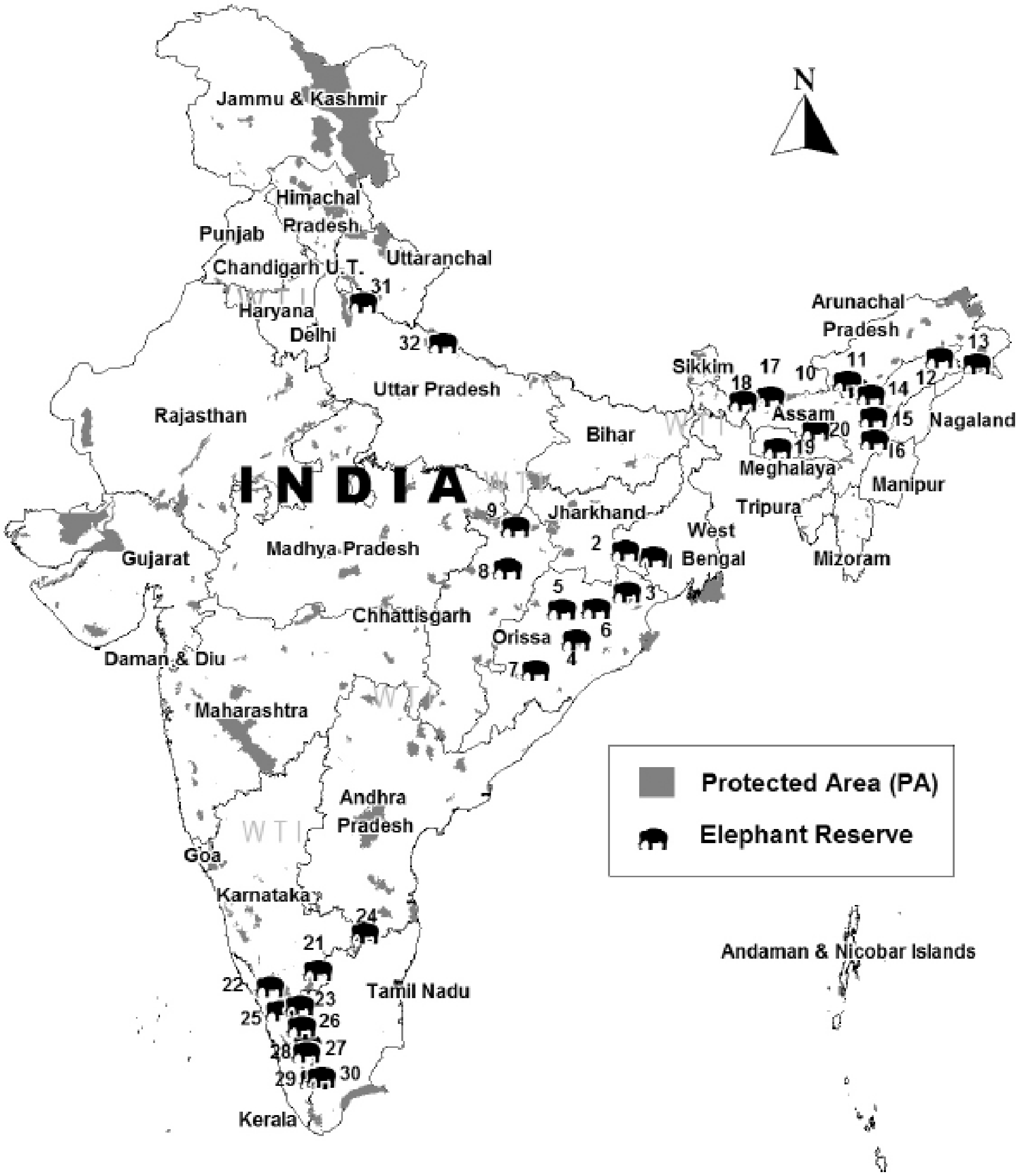
- **India** has by far the **largest number of wild Asian elephants** in the world, estimated at **27,312** according to the 2017 census, about 55% of the species' global population.
- They range in **32 Elephant Reserves** spread over **10 elephant landscapes** in **14 states**, covering about 65,814 sq km of forests in northeast, central, north-west and south India.
- The 'home range' of an elephant herd can vary from an average of about **250 sq km (in Rajaji National Park)** to over **3500 sq km (in the highly degraded, fragmented landscapes of West Bengal)**.
- **Indian (Asian) Elephant (EN)** is listed in **Schedule I of the Indian Wildlife (Protection) Act, 1972, CITES Appendix I and CMS Appendix I**.
- Project Elephant is a **Central Government sponsored** conservation scheme launched in 1992
- Project Elephant is mainly implemented in 16 states — **Arunachal Pradesh, Assam, Andhra Pradesh, Chhattisgarh Jharkhand, Kerala, Karnataka, Meghalaya, Maharashtra, Nagaland, Orissa, TN, Uttarakhand, UP, and WB**.



[Source and Credits: India-Seminar.com]

	Elephant Range		Area (Km²)	Population
1	**East-Central Landscape (South-West Bengal – Jharkhand – Orissa)**	Mayurjharna ER – WB	414	96
		Singhbhum ER – Jharkhand	4530	371

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		Mayurbhanj ER – Odisha	3214	465
		Mahanadi ER – Odisha	1038	464
		Sambalpur ER – Odisha	427	284
		Baitami ER – Odisha	1755	108
		South Orissa ER – Odisha	4216	138
		Lemru ER – Chhattisgarh	450	-
		Badalkhol-Tamorpingla ER – Ch	1048	-
2	**Kameng-Sonitpur Landscape (Arunachal – Assam)**	Kameng ER	1892	
		Sonitpur ER	1420	612
3	**Eastern-South Bank Landscape (Assam – Arunachal)**	Dihing-Patkai ER	937	295
		South Arunachal ER	1958	129
4	**Kaziranga-Karbi Anglong-Intanki Land-scape (Assam – Nagaland)**	Kaziranga-Karbi Anglong ER	3270	1940
		Dhansiri-Lungding ER	2740	275
		Intanki ER	202	30
5	**North Bengal- Greater Manas Landscape (Assam – West Bengal)**	Chirang-Ripu ER	2600	658
		Eastern Dooars ER	978	300-350
6	**Meghalaya Landscape**	Garo Hills ER	3500	1047
		Khasi-hills ER	1331	383
7	**Brahmagiri-Nilgiri-Eastern Ghat Land-scape (Karnataka – Kerala – Tamil Nadu – Andhra)**	Mysore ER	6724	4452
		Wayanad ER	1200	636
		Nilgiri ER	4663	2862
		Rayala ER	766	12
		Nilambur ER	1419	281
		Coimbatore ER	566	329
8	**Anamalai-Nelliampathy – High Range Landscape (Tamil Nadu – Kerala)**	Anamalai ER	1457	179
		Anamudi ER	3728	1726
9	**Periyar-Agasthyamalai Landscape (Kerala – Tamil Nadu)**	Periyar ER	3742	1100
		Srivilliputhur ER	1249	638
10	**North-Western Landscape (Uttarakhand – Uttar Pradesh)**	Shivalik ER	5405	1510
		Uttar Pradesh ER	744	NA
TOTAL (Population data is from 2005)			69583	21370

37.7.1. East-Central Landscape (South-West Bengal – Jharkhand – Orissa)

Mayurjharna Elephant Reserve – West Bengal

- Location: Portion of Midnapore, Bankura, and Purulia District of **West Bengal**.
- On the west, it is contiguous with the **Singhbhum Elephant Reserve of Jharkhand State**.
- On the south, it is contiguous with the **Mayurbhanj Elephant Reserve of Odisha**.

Singhbhum Elephant Reserve – Jharkhand

- Location: **East and West Singhbhum** and Saraikela-Kharsawan Districts of **Jharkhand**.
- It comprises **Saranda Singhbhum Range forests** and **Dalma WLS (near Jamshedpur)**.
- **Saranda forest** (820 km^2) is the **biggest sal forest in Asia**.

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- The forests stand atop one of the world's largest single deposits of **iron ore**.
- **West Singhbhum** accounts for almost the entire share of iron ore mined in the state.
- Iron ore mining has caused significant destruction in the Singhbhum ER.

Mayurbhanj Elephant Reserve – Odisha

- Mayurbhanj (Similipal-Kuldiha-Hadgarh) Elephant Reserve is located in Mayurbhanj and Keonjhar of Odisha.
- It comprises **Similipal TR, Hadgarh WLS** and **Kuldiha WLS**.

Mahanadi Elephant Reserve – Odisha

- It consists of **Satkosia TR** and its adjoining wildlife sanctuaries.
- **Satkosia TR** = **Satkoshia Gorge WLS** + **Baisipalli WLS**.

Sambalpur Elephant Reserve – Odisha

- It is located in the Sambalpur district of Odisha.

Baitami (Brahmani-Baitarani) Elephant Reserve – Odisha

- It covers the portions of Keonjhar, Sundargarh, Angul and Dhenkanal districts.

South Orissa Elephant Reserve – Odisha

- It covers parts of Ganjam, Gajapati, Kandhamal, Rayagada & Kalahandi districts.

Lemru Elephant Reserve – Chhattisgarh

- Lemru Elephant Reserve was declared in 2019 to preserve the **Hasdeo Arand forest** (which has high-quality coal reserves).
- The reserve covers the portions of Surguja, Korba, Jashpur and Raigarh districts in Northern Chhattisgarh.
- The reserve is a refugee for elephants migrating from Jharkhand, **where open cast mining is rampant**.
- But these districts are also a hotbed for coal mining.

Badalkhol-Tamorpingla Elephant Reserve – Chhattisgarh

- It is located in Surajpur District, Chhattisgarh.
- It constitutes Badalkhol WLS and forests between **Badalkhol WLS** and **Guru Ghasidas NP**.

37.7.2. Kameng-Sonitpur Landscape (Arunachal – Assam)

Kameng Elephant Reserve – Arunachal Pradesh

- It is situated in the foothills of the Himalayas of the West Kameng and East Kameng districts of Arunachal Pradesh.
- The **Sessa Orchid Sanctuary**, the **Eaglenest WLS**, the **Pakke TR** are a part of this reserve.

Sonitpur Elephant Reserve – Assam and Arunachal Pradesh

- It is located along the border of Arunachal Pradesh and Assam.
- It is the southern extension of Kameng Elephant Reserve.
- The **Nameri TR** and **Sonai Rupai WLS** are a part of this reserve.

37.7.3. Eastern-South Bank Landscape (Assam – Arunachal)

Dihing-Patkai Elephant Reserve – Assam

- The **Dihing Patkai NP** is a part of Dehing Patkai Elephant Reserve.

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- It is located in the districts of Dibrugarh and Tinsukia of Assam.

South Arunachal Elephant Reserve – Arunachal Pradesh

- **Namdapha TR** is a part of this reserve.
- It is contiguous with the **Dihing-Patkai Elephant Reserve**.

37.7.4. Kaziranga-Karbi Anglong-Intanki Landscape (Assam – Nagaland)

Kaziranga-Karbi Anglong Elephant Reserve – Assam

- It extends from Brahmaputra River to south into the **Karbi Anglong hills**.
- **Kaziranga TR, Nambor-Doigrung WLS, Garampani WLS, Nambor WLS** are a part of the Kaziranga-Karbi Anglong Elephant Reserve (East Karbi Anglong district).

Dhansiri-Lungding Elephant Reserve – Assam

- It extends from the **south of Kaziranga-Karbi Anglong Elephant Reserve** to **Dhansiri River**.
- It is contiguous with the **Intanki Elephant Reserve of Nagaland**.

Intanki Elephant Reserve – Nagaland

- **Ntangki (Intanki) National Park** in south Nagaland is declared as an elephant reserve.

Singphan Elephant Reserve – Nagaland

- It is located in Mon district of Nagaland.
- It is contiguous with the Dihing-Patkai Elephant Reserve of Assam.

37.7.5. North Bengal-Greater Manas Landscape (Assam – West Bengal)

Chirang-Ripu Elephant Reserve – Assam

- Chirang district is an administrative district in the **Bodoland Territorial Region** of Assam.
- Ripu and Chirang are two contiguous reserve forests, in extreme western Assam bordering West Bengal.
- They are part of the buffer zone of **Manas Tiger Reserve**.
- These forests have the largest known population of the endangered **Golden Langur (EN)**.

- Ripu-Chirang is a conservation link between **Buxa Tiger Reserve (in WB)-Phipsu wildlife sanctuary (in Bhutan)-Royal Manas National Park (in Bhutan)-Manas National Park**.

Eastern Dooars Elephant Reserve – West Bengal

- Eastern Dooars Elephant Reserve is located in Jalpaiguri district of West Bengal.
- It consists of **Jaldapara NP, Pakhi Bitan WLS** and parts of **Buxa TR**.

Dooars or Duars

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- The Dooars or Duars are the alluvial floodplains that lie south of the outer foothills of the Himalayas and north of the Brahmaputra River basin.
- This region is about 30 km wide and stretches over 350 km from the **Teesta River** in WB to the **Dhansiri River** in Assam.

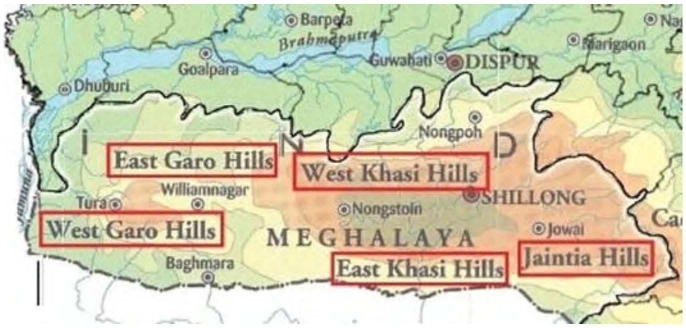
37.7.6. Meghalaya Landscape

Garo Hills Elephant Reserve – Meghalaya

- Garo Hills Elephant Reserve is situated in the East and West Garo Hills of Meghalaya.
- It consists of Nokrek NP, Balpakram NP and Siju WLS and the surrounding Reserved Forests.

Khasi-hills Elephant Reserve – Meghalaya

- Khasi-hills Elephant Reserve is situated in West Khasi Hills and South West Khasi Hills of Meghalaya.



37.7.7. Brahmagiri-Nilgiri-Eastern Ghat Landscape (Karnataka – Kerala – Tamil Nadu – Andhra)

Mysore Elephant Reserve – Karnataka

- It is an integral part of the **Muttodi (Bhadra TR) – Brahmagiri – Nagarholle TR – Bandipur TR** Corridor.
- Nagarhole TR and Bandipur TR are a part of the Nilgiri Biosphere Reserve.

Wayanad Elephant Reserve – Kerala

- Wayanad Wildlife Sanctuary of Kerala is declared as an elephant reserve.
- It is contiguous with the Mysore Elephant Reserve and Nilgiri Elephant Reserve.
- **Wayanad WLS** and **Aralam WLS** are a part of the Nilgiri Biosphere Reserve.

Nilgiri Elephant Reserve – Tamil Nadu

- Nilgiri Elephant Reserve consists of the entire Nilgiri Biosphere Reserve of Tamil Nadu.

Nilgiri Elephant Corridor

- **SC recently upheld the Tamil Nadu (state) government's authority to notify an 'elephant corridor'** and protect the migratory path of the animals through the Nilgiri Biosphere Reserve.
- It was the State's duty to protect a **"keystone species"** such as **elephants** – Supreme Court.
- It is the largest protected forest area in India, spanning across **Tamil Nadu, Karnataka & Kerala.**
- It is situated in the **Masinagudi area** near the **Mudumalai National Park** in the Nilgris district.
- The corridor is situated in the ecologically fragile **Sigur plateau**, which connects the Western & the Eastern Ghats & sustains elephant populations & their genetic diversity.

Rayala Elephant Reserve – Andhra Pradesh

- **Kaundinya Wildlife Sanctuary** in Andhra Pradesh is declared as **Rayala Elephant Reserve**.

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- The sanctuary is situated in the region where the Kolar Plateau ends and slopes down into the plains of Tamil Nadu.

Nilambur Elephant Reserve – Kerala

- The reserve spreads across the districts of Palakkad, Malappuram and Kozhikkode.
- **Salient Valley NP, New Amarambalam WLS** are a part of the Nilambur Elephant Reserve.
- It is contiguous with the Waynad ER and Nilgiri ER.

Coimbatore Elephant Reserve – Tamil Nadu

- It consists of forests near Coimbatore in Tamil Nadu adjacent to the Nilambur Elephant Reserve.

Anamalai-Nelliampathy – High Range Landscape (Tamil Nadu – Kerala)

- **Anamudi Elephant Reserve** and **Anamalai Elephant Reserve** are separated from Nilgiris by **Palakkad Gap**.

Anamalai Elephant Reserve – Tamil Nadu

- **Anamalai Tiger Reserve** is declared as Anamalai Elephant Reserve.
- It is contiguous with the Anamudi Elephant Reserve of Kerala.

Anamudi Elephant Reserve – Kerala

- **Nelliampathy Forest, Parambikulam TR** and **Munnar Wildlife Division** of Idukki district are a part of Anamudi ER.
- **Anamudi Shola NP, Chinnar WLS, Eravikulam NP, Kurinjimala WLS, Mathikettan Shola NP, Pampadum Shola NP** are all part of Munnar Wildlife Division.

37.7.8. Periyar-Agasthyamalai Landscape (Kerala – Tamil Nadu)

Periyar Elephant Reserve – Kerala

- **Periyar National Park and Wildlife Sanctuary** was declared as an elephant reserve.
- The park is located high in the **Cardamom Hills** and **Pandalam Hills** of the south Western Ghats along the TN border.

Srivilliputhur Elephant Reserve

- **Srivilliputhur Grizzled Squirrel Wildlife Sanctuary** was established to protect the **grizzled giant squirrel (NT)**.
- It was later declared as an elephant reserve. It is contiguous with the Periyar Elephant Reserve of Kerala.

37.7.9. North-Western Landscape (Uttarakhand – Uttar Pradesh)

Shivalik Elephant Reserve

- Shivalik Elephant Reserve constitutes **Shivalik Hills of Uttarakhand**.
- It constitutes **Jim Corbett TR, Rajaji TR, Sonanadi WLS**, and Dehra Dun forests apart from other Shivalik forest divisions sprawling in **Garhwal** and **Kumaon hills**.

Uttar Pradesh Elephant Reserve

- Uttar Pradesh Elephant Reserve constitutes Shivalik forest division in Saharanpur & Bijnore districts adjoining the Shivalik Hills of Uttarakhand (Shivalik Elephant Reserve).

37.8. Tiger, Leopard and Elephant population by state

State	Tiger Population		State	Elephant Population		State	Lopard Population

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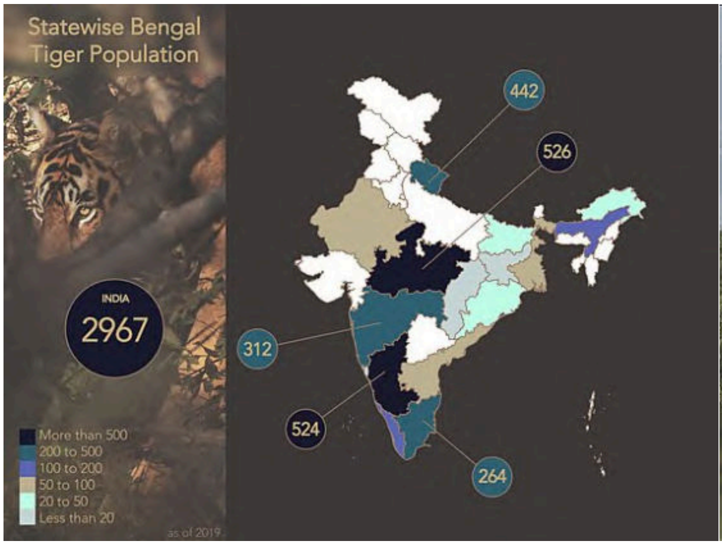
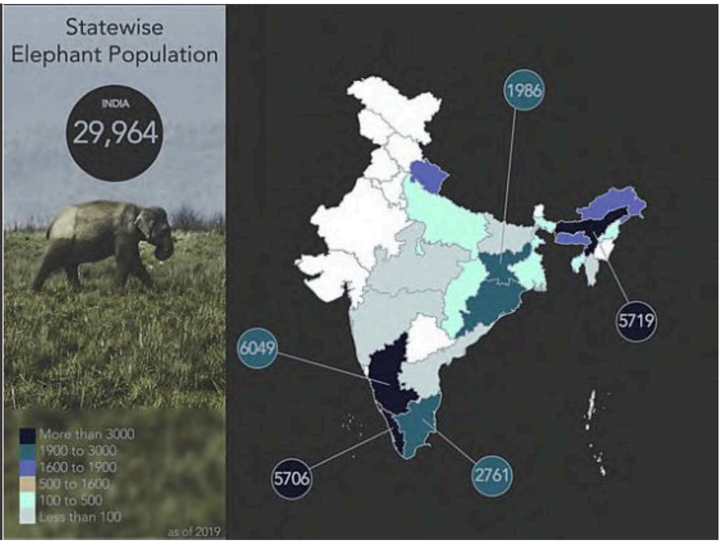
1.	**Madhya Pradesh**	**526**	**1.**	**Karnataka**	**6049**	**1.**	**Assam**	**2,487**
2.	**Karnataka**	**524**	**2.**	**Assam**	**5719**	**2.**	**Madhya Pradesh**	**1,817**
3.	**Uttarakhand**	**442**	**3.**	**Kerala**	**5706**	**3.**	**Gujarat**	**1,355**
4.	**Maharashtra**	**312**	**4.**	**Tamil Nadu**	**2761**	**4.**	**Karnataka**	**1,129**
5.	**Tamil Nadu**	**264**	**5.**	**Jharkhand**	**1986**	**5.**	**Maharashtra**	**905**
6.	**Assam**	**190**	**6.**	**Odisha**	**1976**	**6.**	**Chhattisgarh**	**846**
7.	**Kerala**	**190**	**7.**	**Uttarakhand**	**1839**	**7.**	**Tamil Nadu**	**815**





Tiger, Leopard and Elephant population by state				
State	**Tigers (2019)**	**Elephants (2019)**	**Leopards (2015)**	**Asiatic lion (2017)**
Andhra Pradesh	58	80	343	0
Arunachal Pradesh	29	1614	489	0
Assam	**190**	**5719**	**2,487**	0
Bihar	31	25	32	0
Chhattisgarh	19	247	846	0
Goa	3	0	71	0
Gujarat	0	0	**1,355**	**650**
Jharkhand	5	**1986**	29	0
Karnataka	**524**	**6049**	1,129	0
Kerala	190	**5706**	472	0
Madhya Pradesh	**526**	7	**1,817**	0
Maharashtra	**312**	6	905	0
Meghalaya	0	1754	0	0
Mizoram	0	7	0	0
Nagaland	0	446	0	0
Odisha	28	1976	345	0
Rajasthan	69	0	434	0
Tamil Nadu	**264**	**2761**	815	0
Tripura	0	102	0	0
Uttar Pradesh	173	232	194	0

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Uttarakhand	**442**	**1839**	703	0
West Bengal	88	194	0	0
Total	**2,967**	**29,964**	**12,466**	**650**

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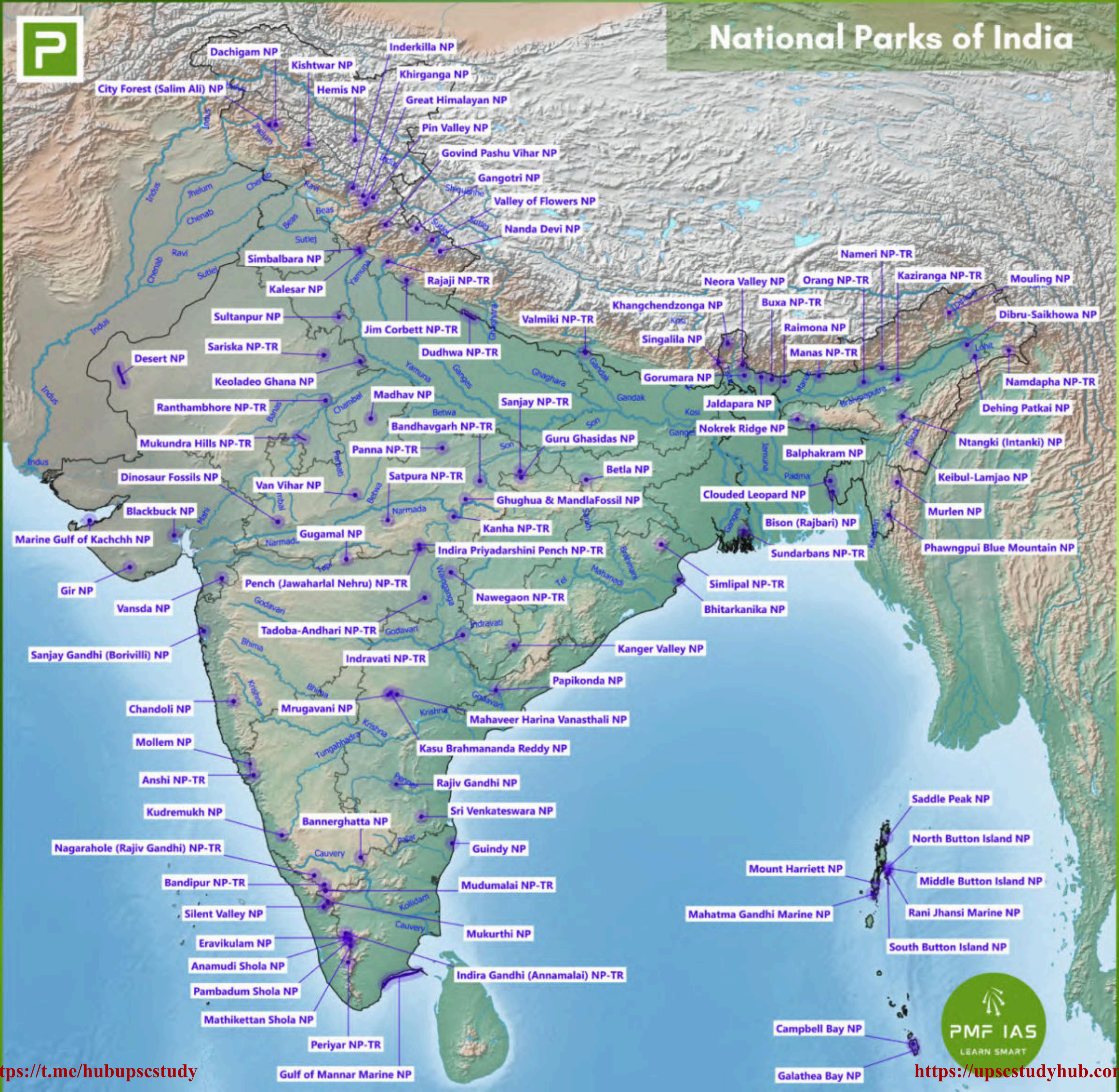

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